CANMET

Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie

Energy Research Laboratories

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Energy, Mines and Resources Canada

Énergie, Mines et Ressources Canada

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FOREWORD

One of the principal objectives of CANMET's fuels technology sub-activity is to develop the technologies required to optimize the recovery and utilization of Canadian fossil fuels in an environmentally acceptable manner, to produce synthetic fuels from non-conventional sources; to integrate synthetic fuels into the end-use system support; and to provide policy support. The Energy Research Laboratories (ERL) responds to this R&D objective by developing technologies in partnership with the oil, gas and coal industries and making industry more efficient through the use of improved energy conservation methods.

Important input and guidance on project selection and implementation are provided by advisory councils comprised of experts primarily from industry. Shared-cost projects with industry are underway in-house, and major elements are undertaken in the private sector through shared-cost contract R&D programs.

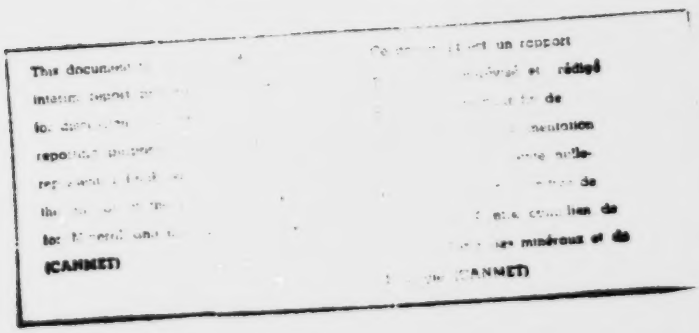
An Office of Business Development has been created within ERL to strengthen our ties with industry and to improve the marketing of our expertise and facilities. All R&D projects are being evaluated and managed according to proven business management criteria to increase the industrial and commercial relevancy of our projects.

This report summarizes the activities of ERL during fiscal year 1987/88 and is intended as a report to CANMET management and staff and as a working document for preparing the CANMET Review and other branch publications. The division's activities for 1987/88 are reported according to sub-sub-activity followed by a brief review of the projects under each. The resources allotted for each sub-sub-activity are given in Table 1.

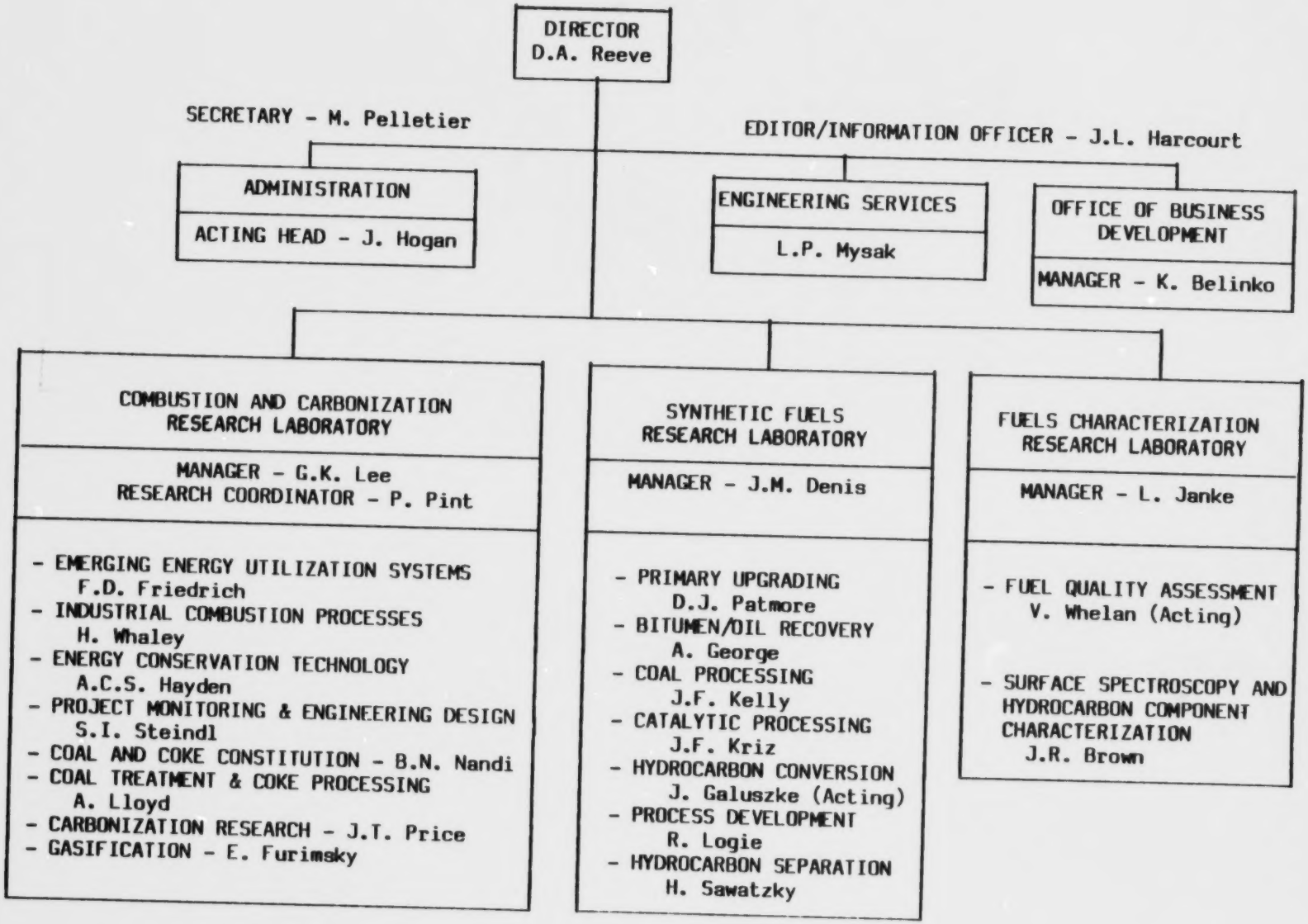
D.A. Reeve

D.A. Reeve
Director

MICROMEDIA



ENERGY RESEARCH LABORATORIES



RESOURCES - 1987/88

SUB-SUB-ACTIVITY	PY	OPERATING $K	CAPITAL $K	CONTRACTS $K	TOTAL $K
Recovery of Bitumen and Heavy Oil	3	40	10	1 527	1 577
Bitumen and Heavy Oil Upgrading	30	300	360	775	1 435
Upgrading of Synthetic Crudes & Distillates and Utilization of Residues	17	465	430	820	1 715
Conversion of Natural Gas to Liquid Fuels	6.5	295	307	436	1 038
Development of Coprocessing and Coal Conversion Technologies	23	75	83	350	508
Gasification	5.5	195	69	264	528
Metallurgical Fuels	20	123	147	104	374
Pulverized Coal Combustion	14	216	146	220	582
Fluidized Bed Combustion	11	170	312	283	765
New Coal-Based Fuels	2	73	58	288	419
Combustion Technologies for Pollution Abatement	2	120	76	285	481
Conservation in Residential, Commercial and Industrial Systems	8.5	125	93	363	581
Biomass Fuels for Residential and Industrial Utilization	3.5	33	39	40	112
Management and Support	19	1 512	368	-	1 880
TOTAL	165	3 742	2 498	5 755	11 995

AVANT-PROPOS

Un objectif principal de la sous-activité de CANMET sur la technologie des combustibles est de mettre au point la technologie qui permettra de maximiser la récupération et l'utilisation des combustibles fossiles canadiens d'une façon qui respecte l'environnement; produire des combustibles synthétiques à partir de sources non-classiques; intégrer les combustibles synthétiques adoptés. Pour atteindre cet objectif, les Laboratoires de recherche sur l'énergie (LRE) mènent des travaux de R-D, en collaboration avec l'industrie du pétrole, du gaz naturel et du charbon, pour mettre au point des techniques qui permettront à l'industrie d'améliorer son efficacité par de meilleures techniques de conservation de l'énergie.

Des comités consultatifs formés principalement de représentants compétents de l'industrie aident à orienter le choix et le déroulement des projets. Des projets à frais partagés avec l'industrie sont en cours dans les laboratoires et des travaux importants sont menés dans le secteur industriel dans le cadre de contrats de R-D à frais partagés.

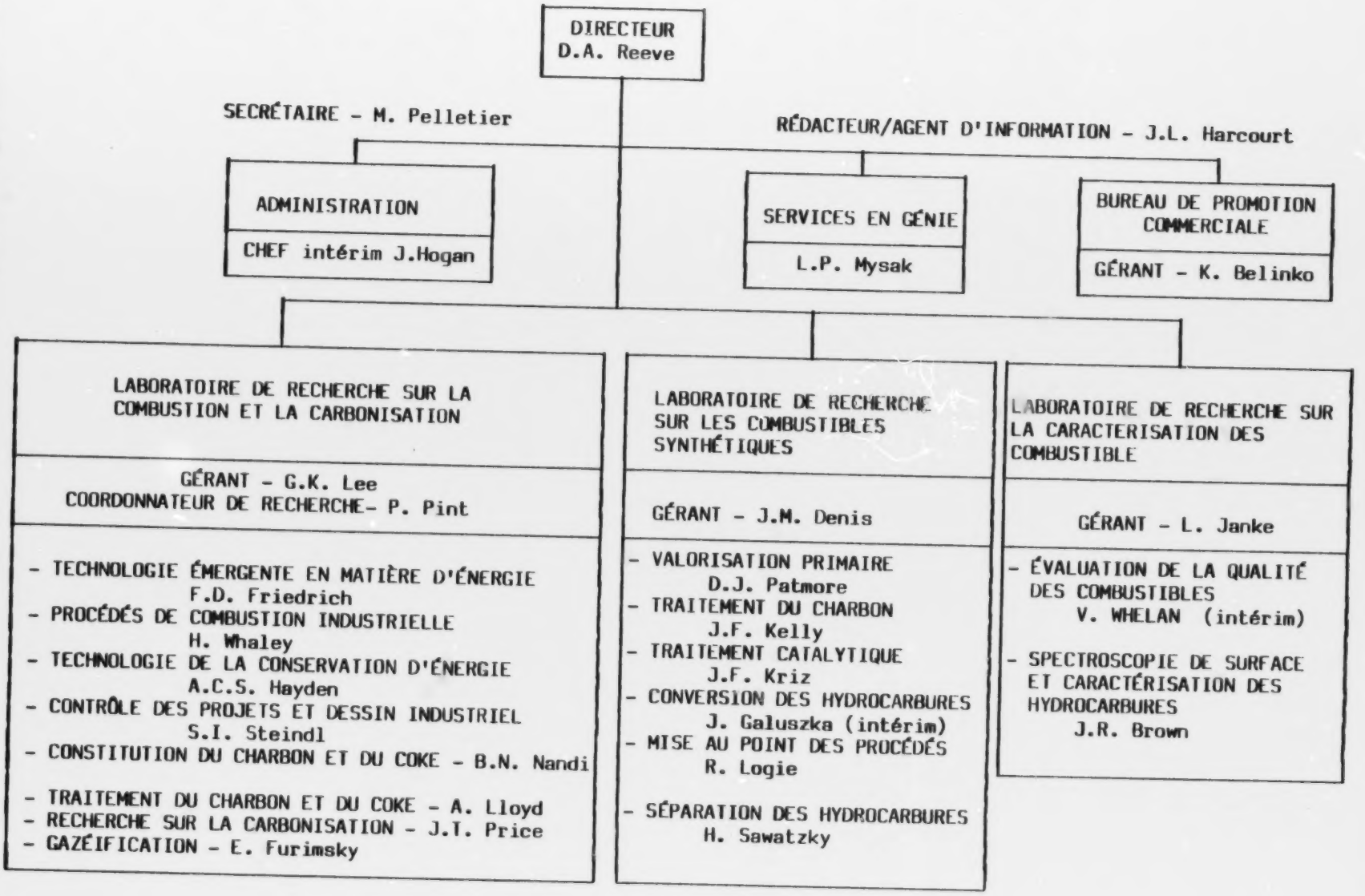
Le Bureau de la promotion commerciale des LRE a été créé pour renforcer les liens avec L'industrie et développer le marketing de notre expertise et de notre équipement. Tous les projets R-D sont évalués et gérés selon des critères d'exploitation éprouvés afin d'accroître leur pertinence commerciale et industrielle.

Le présent rapport résume les activités des Laboratoires de recherche sur l'énergie pour l'exercice financier 1987-1988. Ce rapport, destiné à la direction et au personnel de CANMET, constitue aussi un document de travail pour la préparation de la revue de CANMET et d'autres publications de la Direction. Ces activités pour l'année 1987/88 sont regroupées selon chaque sous-sous-activité et sont brièvement passées en revue.

D.A. Reeve.

D.A. Reeve
Directeur

LABORATOIRES DE RECHERCHE SUR L'ÉNERGIE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RECOVERY OF BITUMEN AND HEAVY OIL

OBJECTIVE

To research and develop extraction and in situ methods for recovery of oil sand bitumen and heavy oils.

ACHIEVEMENTS

ERL, in cooperation with the University of Alberta, designed, commissioned and operated a physical simulator for the study of recovery of heavy oil from marginal reservoirs. This technology has been transferred to the Saskatchewan Research Council.

In a cooperative program with AOSTRA, UMATAC and Environment Canada, ERL carried out a successful feasibility study for the use of the Taciuk thermal process for treatment and partial upgrading of sludges and residua from bitumen and heavy oil production processes.

DEVELOPMENT OF NEW TECHNOLOGY FOR RECOVERY OF ATHABASCA BITUMEN

(1) UMATEC (Taciuk) Process

ERL was prepared to participate in a field demonstration of this thermal process for extraction and partial upgrading of bitumen from mined oil sand. However, because of the slump in world oil prices, the large scale demonstration of the Taciuk thermal process is now in a holding pattern. However, CANMET is supporting a smaller scale project with AOSTRA and Environment Canada for the utilization of this technology to extract bitumen from sludges and residual petroleum wastes.

(2) Horizontal Well Gravity Drainage Technology

In cooperation with AOSTRA and industry, ERL is developing and conducting field trials of novel concepts of horizontal well in situ steam recovery technology at the AOSTRA Underground Test Facility (UTF) in the Fort McMurray area of the Athabasca deposit. This three-year pre-pilot program utilizing horizontal wells should also be of particular relevance to in situ recovery from the thin heavy oil reservoirs of Saskatchewan.

LEVERAGED IN SITU RECOVERY R&D

In situ production technology is inherently more compatible than that of Suncor and Syncrude with phased incremental production of bitumen and heavy oil and therefore deserves special attention during this decade. Significant resources are devoted to contracts which generate basic information in selected key areas, for example, physical and numerical modelling; and to contracts which stimulate technology developments such as new concepts of horizontal well technology aimed at increasing the production of bitumen and heavy oil in Western Canada particularly from problem reservoirs in both Alberta and Saskatchewan.

Contract activity supports a range of 50/50 cost-shared studies with industry, cooperative studies with AOSTRA and bilateral studies under a US/Canada Memorandum of Understanding for Cooperative R&D in Oil Sands and Heavy Oil. These studies require a measure of federal funds to share the risk of technology transfer to field situations.

Contracts

1. "Steam injection experiments in scaled physical models for simulating marginal heavy oil reservoirs - Phase II and III"

2. "Impact of steam additives on the productivity of the cyclic steam stimulation process"

3. "Study of the effect of thermal alteration on conformance efficiency in in-situ thermal recovery process"

4. "Field test of a novel microbial system to improve reservoir conformance in a watered out heavy oilfield"

5. "Evaluation of a heavy oil recovery process using a novel combination of injections"

6. "Numerical simulation of steam injection in bitumen and heavy oil reservoirs"

7. "Study of factors affecting the flocculation of asphaltenes in bitumen, heavy oil and asphalt solutions"

COOPERATIVE GENERIC R&D WITH AOSTRA, OTHER PROVINCES AND THE US

Canada and the United States signed a Memorandum of Understanding for Cooperation in R&D on Oil Sands and Heavy Oil in 1979. The US participates through its Department of Energy. The Canadian participants are Energy, Mines and Resources Canada (CANMET), the Saskatchewan Department of Energy and Mines and the Alberta Oil Sands Technology and Research Authority (AOSTRA). Relevant implementing agreements are:

- resource characterization
- steam additives in bitumen/heavy oil recovery
- exchange of information
- remote sensing of frontal movements of steam in in situ recovery process

Such activities promote awareness of mutual interests in critical gap and generic R&D needs and facilitate exchange of information at senior research and policy influencing levels.

CANMET has also contributed by consultative scientific/technical advice, evaluation and direction via the Management Committee of the Canada-Saskatchewan Heavy Oil/Fossil Fuel Agreement for research conducted or subcontracted by the Petroleum Division of the Saskatchewan Research Council and for contracts by Saskatchewan Energy and Mines to industry for research and field testing/demonstration programs. The Agreement ended in March 1988.

Contracts

1. "Steam recovery processes with addition of non-condensible gases - a mechanistic study"

2. Canada/US publication "Characterization of oil sands resources"

3. Canada/US publication "Effect of thermal recovery methods on the chemical characteristics of heavy oil".

BITUMEN AND HEAVY OIL UPGRADING

OBJECTIVE

To improve existing and develop novel technologies for upgrading Canada's bitumen and heavy oil to feedstock for oil refining.

ACHIEVEMENTS

The Petro-Canada demonstration unit for the CANMET hydrocracking process continues to run successfully. A high conversion test run using Cold Lake feed was completed in which ERL scientists took part. Pilot plant runs were carried out at ERL to assist in choosing an additive for the commercial process.

A cost-shared project with Ultramar has shown that vacuum pyrolysis technology can fulfill the three criteria necessary for processing refinery residues, i.e., recovery of oil for recycling, environmentally safe residue and economic viability. Larger scale tests will be conducted.

VACUUM PYROLYSIS

This technology is being applied to refinery waste residues as a means of eliminating the environmental problems associated with their storage and disposal. A techno-economic evaluation has been completed and the process is ready to be piloted.

ROTARY COKING DRUM

This technology is being developed for upgrading tar sands using a rotary coking drum followed by fluidized bed combustion of the coke produced. Fabrication of the equipment is in progress.

UPGRADING HEAVY OIL EMULSIONS

A new concept for simultaneously upgrading and dewatering heavy oil emulsions uses carbon monoxide or carbon monoxide/hydrogen mixtures. This process is being tested in a series of autoclave tests. If results are promising pilot tests will begin.

CHEMICAL TRANSFORMATIONS DURING CATALYTIC HYDROCRACKING

Although this project is strictly a fundamental study to elucidate the chemical reactions occurring during catalytic and non-catalytic upgrading of bitumen, the findings could ultimately lead to technological improvements. This project is being carried out jointly with four Canadian companies.

Significant progress has been made in developing a simplified additive preparation scheme which would reduce capital and operating costs. The concepts will be tested in the 5000 BPD demonstration plant in Petro-Canada's Montreal refinery.

Other projects have included hydrodynamic studies at the University of Waterloo and collaborative work with Alcan on the utilization of residual pitch as a binder in electrode manufacturing.

A major initiative was undertaken to promote a program that will encourage greater industrial participation in catalyst development. The program will focus on problems associated with upgrading Canadian heavy crudes. Since these problems are unique to Canada multi-national catalyst manufacturers have not addressed them adequately. One of the objectives is to organize a consortium with the participation of at least one catalyst manufacturer to serve as an outlet for new technological advancements in Canada.

Advice and consultation were provided to companies wishing to explore technology transfer opportunities in upgrading. This service will continue, with greater emphasis on aligning in-house programs to benefit industrial sponsors.

FUNDAMENTAL STUDIES

Hydrogen Consumption

A report was issued describing for the first time the catalytic effect of iron based coke-inhibiting additives on hydrogen consumption in hydrocracking of heavy oils. Mechanisms involved in coke inhibition and hydrocracking were proposed.

Vapour/Liquid Equilibrium Study

Two reports were issued on vapour/liquid equilibrium studies carried out in the hydrocracking pilot plant. Experimental data were compared with predictions of a commercial package and an improved in-house correlation was derived.

Mössbauer

To determine the nature of the active iron species present during hydrocracking of heavy oil using iron based additives, a systematic study of autoclave and pilot plant samples was carried out using Mössbauer spectroscopy. A new, as yet unidentified species was observed and appears to play an important role in the performance of such additives.

Hydrodynamics

Dual energy gamma-ray densitometry was used for the first time to monitor the sedimentation of multi-sized solids suspended in liquid. A numerical simulation was also carried out to model the variation with time of the pressure drops for pulsing gas flow across an orifice and for pulsing gas liquid two-phase flows through the preheater section of a continuous hydrocracking pilot plant. This will enable more accurate gas flow measurement and control.

Microscopy of Reactor Samples

Quantitative microscopy proved to be a valuable tool for rating the effectiveness of different additives in inhibiting mesophase formation and growth. By combining this technique with specially designed pilot plant experiments, a much more rapid testing procedure was developed.

Additive Development

Novel coke inhibiting additives were tested in the autoclave. In addition, an additive prepared by a much simplified procedure was assessed in the pilot plant.

Dual Energy Densitometry

A novel dual energy gamma densitometer for rapid ash analysis was commissioned and calibrated. This method allows ash measurements to be made in 15 minutes instead of 6 hours required for the standard ASTM method. This is important for applications where ash concentration must be controlled.

PROCESS DEVELOPMENT OF HYDROCRACKING TECHNOLOGIES

Bench Scale Program

Work continued on developing new process control software for the bench scale unit. Commissioning of this unit has been rescheduled to next fiscal year.

Accumulation vs Transport

A comparison of pilot plant operation in the solids accumulation and transport modes was completed. The effect of additive particle size on the accumulation of solids in the hydrocracking pilot plant was assessed.

Feasibility of Using Recyled Solids

The activity of recycled reactor solids towards coke inhibition was assessed by means of a series of autoclave tests. The results indicated a potential for replacing some of the additive with recycled material thereby reducing the overall additive requirement.

CANMET HYDROCRACKING SUPPORT

Additive Comparison Pilot Plant Runs

A new pilot plant additive testing procedure was designed and successfully tested. Six coke inhibiting additives were compared and their activity correlated with composition. The beneficial role of coal was identified by quantitative microscopic analyses. This information is important to the design of improved additive preparation facilities.

Additive Testing

Autoclave experiments were used to evaluate a series of new additives prepared by Petro-Canada for the CANMET demonstration plant.

Demonstration Plant Process Monitoring

ERL staff were assigned to the demonstration plant to monitor the performance of the unit during a special run using Cold Lake feedstock.

Calibration of Gamma Scanner

The gamma densitometers installed at the hydrocracking demonstration plant in Montreal were recalibrated by in-house experiments and on-site inspection and testing. A calibration curve was derived and a troubleshooting procedure was developed to test the densitometers during plant operation.

NEW UPGRADING PROCESS

Alternative Energy Sources to Promote Hydrocracking

An experimental ultrasound autoclave unit was constructed and commissioned. The efficiency of the custom designed ultrasound generator was tested and found to be satisfactory. The unit will be used to assess the use of ultrasound energy in heavy oil upgrading.

Review of Viscosity Reduction Processes

A review and assessment of existing viscosity reduction processes were initiated.

Supercritical Extraction

An extensive literature search was carried out on supercritical extraction and the design of an experimental system to assess its application to heavy oil upgrading was commenced.

Membrane Separation

Low temperature non-reactive upgrading of heavy oil is being investigated in collaboration with NRC. It has been shown that deleterious components such as vanadium, nickel, nitrogen and sulphur can be removed from crude oil along with heavier components such as asphaltenes. NRC is performing ultrafiltration experiments in existing equipment. CANMET scientists acquired samples of Lloydminster, Mydale, and Athabasca heavy oils from Western Canada and established the operating conditions for the ultrafiltration experiments. Compositional analyses and bench scale reactor tests will be conducted at ERL.

DEVELOPMENT OF CATALYTIC UPGRADING PROCESSES

Effect of Catalyst Promoters

Experiments were conducted to determine the effects of fluorine and lithium as secondary promoters in catalytic hydrocracking using $Ni/Mo/Al_2O_3$ catalysts. Athabasca bitumen was used as the feedstock. Lithium did not impede deactivation of the catalyst. The addition of fluorine enhanced cracking without affecting hydrogenation. The HDS activities and deactivation remained unchanged.

Dispersed Slurry Catalysts

Experimental evaluation of coking propensities using highly dispersed slurry catalysts such as molybdenum naphthenate and transition metal carbonyls is underway. Boscan heavy oil is being used as the test feedstock.

Pitch Cracking and Gasification

In these experiments, a vacuum tower bottoms pitch from Cold Lake heavy oil contacted the catalyst in a fluidized bed. Subsequently a micro-balance reactor was used to perform cracking experiments. The results were similar to those expected for the cracking of gas oils except the residual feedstock performed best at much greater catalyst/oil ratios. The micro-balance reactor was also used to gasify the large quantity of coke deposits using the carbon-steam reaction.

Hydrocracking

High pressure hydrocracking experiments were performed using Athabasca bitumen. Alumina supported hydrocracking catalysts were compared with carbon supported catalysts. Asphaltene conversions and turnover frequencies of the carbon supported catalysts are being compared with those of the alumina catalysts. A visiting scientist from the University of Jeddah is working on this joint project.

UPGRADING OF SYNTHETIC CRUDE DISTILLATES AND UTILIZATION OF RESIDUES

OBJECTIVE

To develop new technologies for refining synthetic crude oil and for utilizing residues from conventional processing.

ACHIEVEMENTS

A feasibility study on a low-severity hydrogenation process for upgrading jet and diesel fuels was completed. Several possible industrial applications of this process, which was developed at ERL, have been identified, and the possibilities for commercialization are being explored.

A novel, lightweight vacuum transfer vessel has been developed. This permits the transfer of air-sensitive solid specimens between ultra-high vacuum chambers equipped with the necessary mating hardware. The self-contained unit maintains a 10^{-8} torr pressure for at least 72 h.

HYDROGENATION OF AROMATICS AND CONVERSION OF NAPHTHENES IN SYNTHETIC CRUDE DISTILLATES FOR DIESEL AND JET FUEL PRODUCTION

Work continued on developing and screening large pore nickel catalysts for low severity hydroprocessing of synthetic mid-distillates. Other research carried out under contract concerned the application of new technology involving metal vapour synthesis techniques for the preparation of supported metal clusters. Screening of bimetallic clusters revealed important effects concerning different selectivities for hydrogenation, dehydrogenation and hydrogenolysis reactions of hydrocarbons.

A feasibility study of a low severity catalytic hydrogenation process for upgrading jet and diesel fuels was completed under contract. The study identified four short term and two to four long-term refinery applications in Canada. Commercialization options for the process are being explored. Other work involved an extensive study of the kinetics and thermodynamics of hydrogenation of synthetic middle distillate fuels. A preliminary study was carried out on the shock tube combustion of hydrocarbon components of synthetic jet fuels.

Novel Concepts for Refining Synthetic Crude Distillates

A program of hydrotreating liquid products derived from CANMET hydrocracking and coprocessing coal/bitumen was initiated. Comparisons of the qualities of distillate fuels from both primary processes will be made and secondary processing options will be evaluated. Hydrotreating runs on CANMET hydrocracked naphtha were carried out. Work was conducted on improving catalyst presulphiding. Analysis of the hydrotreated products for sulphur, nitrogen and aromatics conversion was obtained and used to assess the effectiveness of the operations.

Work on the development of catalysts for two-stage hydroprocessing of synthetic crude gas oil was carried out by a visiting research scientist from the Japanese Government National Chemical Laboratory for Industry. Results indicated that less severe operating conditions for the second stage are needed due to the removal of nitrogen compounds in the feed. Further cost-shared work was carried out with Petro-Canada to increase yield and improve product quality in the hydrocracking of nitrogen containing heavy gas oils.

A new study was initiated to investigate the metal poisoning effects on catalysts and octane enhancement of gasoline using a pulse microcatalytic reactor. The newly designed reactor can produce instantaneous as well as accumulative cracking results based on an incremental short contact time (between oil and catalyst) which is much closer to commercial riser reactor operating conditions. The project also concerns kinetic modelling which could lead to the development of improved technology for the Canadian petroleum industry. Other contract work concerned fluid catalytic cracking of non-conventional gas oils and the degradation behaviour of a metals-tolerant catalyst by catalytic cracking of pure components or of blends commonly found in heavy oils or synthetic crudes.

Laboratory Separation of Synthetic Crude Distillate Fractions

A comprehensive experimental program was carried out to study the separa tion of heteroatomic components from synthetic crudes using adsorption methods. Various candidate sorbents were screened to determine the retention of diverse nitrogenous and oxygenous compounds.

Several potential sorbents were identified for more in depth studies and optimium experimental conditions were also determined. A fully automated adsorption/desorption reactor unit is undergoing commissioning.

A cost-shared contract has shown experimentally that extractions of poisonous nitrogenous compounds significantly improved the catalytic cracking of gas oil.

A cost-shared project with Petro-Canada involved the pilot scale formation of C4, C5 and C6 ethers, their evaluation as blending agents in octane number tests and, through linear programming studies, the determination of the feasibility of the process for refinery operations. Research on the use of membrane technology in the production of octane boosters also continued under contract. The work is concerned with the use of membranes in both reverse osmosis and pervaporation for the removal of unreacted methanol from reactor effluents containing C4 and C5 ethereal products. Preliminary results show that reverse osmosis is performance limited while pervaporation is technically viable. The economic viability of pervaporation will therefore be assessed when the work is complete. Other areas of interest in membrane research are concerned with the segregation of aromatics from saturates in distillate streams and with the development of membrane catalysts for hydrogenation and dehydrogenation of light petroleum distillates.

PRODUCTION AND TESTING OF ASPHALT BLENDS CONTAINING RESIDUALS FROM ADVANCED BITUMEN/HEAVY OIL CONVERSION PROCESSES

Asphalt blends with desirable penetration properties were obtained by distillation of CANMET hydrocracking heavy ends. Ductility specifications were met but high temperature viscosities were too low and after thin film oven tests much of the favourable ductility properties were lost. These asphalts were prepared by removing materials believed to be ash and coke and this was thought to improve the ductility. However, it was apparent that other asphaltic components were also removed. Thus the solubility characteristics of processing residues were studied and it is now believed that the less soluble residue components are more dependent on peptization than those that are more soluble. Furthermore, precipitation can be caused by slight changes in the environment of the less soluble components which may explain the changes in ductility. Therefore, the less soluble residue components might not be tolerated for asphalt blending.

The required level of solubility in these residues is not known at this time. However, the solubility level equivalent to that of asphaltenes in virgin asphalts is being considered as an appropriate guide. Thus to attain this level, a +525°C residue from an 80% conversion run on Cold Lake bitumen was fractionated and 22% was removed as undesirable for asphalt production. The desired fraction had a hydrogen content of about 8.5% while the fraction removed was about 5.0%. It was found possible to blend the desired fraction in significantly larger proportions with conventional virgin asphalt than the unfractionated residues and the asphaltic products obtained far exceeded the required ductility values. Similar favourable results were found from blends of the desired fraction with heavy vacuum gas oils from both virgin and synthetic crudes.

CONVERSION OF NATURAL GAS TO LIQUID FUELS

OBJECTIVE

To promote the development and commercialization of novel technologies for the conversion of natural gas into fuels, fuel additives and petrochemical feedstocks.

ACHIEVEMENTS

A facility for chemical characterization of catalyst surfaces has been completed and demonstrated. The system permits temperature programmed desorption or reaction, high temperature and high vacuum operation, and combined Fourier transform infrared and mass spectrometric analysis.

DESIGN AND EVALUATION OF NOVEL PROCESSES FOR THE DIRECT CONVERSION OF NATURAL GAS INTO LIQUID FUELS

Oxidative Coupling

One of the most promising methods proposed for converting methane to liquid fuels is the oxidative coupling reaction. The ethylene produced is valuable as a raw material for the manufacture of petrochemicals or as an intermediate to be polymerized to liquid fuels. Further improvement to catalysts will be required to make this process commercially attractive. Novel oxide catalysts that could convert methane at lower temperatures have been designed and are being tested in house.

Research in the oxidative coupling of methane to ethylene and ethane is being carried out under contract by Institut de Recherche d'Electricité du Québec (IREQ) with joint funding by Gaz Métropolitain, IREQ and CANMET. Substantial progress has been made in understanding the basic factors affecting the activity of selective oxide catalysts. This information has been used to design a better catalyst. High selectivities (98%) to ethylene and methane have been obtained at a relatively high methane conversion (30%). These results are among the best ever reported. A second cost-shared venture funded jointly by the Alberta Research Council and CANMET is underway.

A joint research agreement between the Centre de Recherche Industrielle du Québec (CRIQ) and CANMET has resulted in the secondment of an industrial researcher to our laboratories to pursue common research interests.

In Situ Chemical Characterization of Catalyst Surfaces

A comprehensive and innovative in-house facility for in situ chemical characterization of catalyst surfaces during C1 activation studies was completed and demonstrated. Features include temperature programmed desorption/reaction, high temperature and high vacuum operation, combined Fourier transform infrared and mass spectrometric analysis.

Direct Conversion Using a Hollow Cathode Arc

Work continued on the optimization of the hollow cathode arc process for the direct conversion of natural gas. The objective was to investigate ways to control the polymerization reaction in order to obtain liquid products. Results have shown a high methane conversion (90%) with selectivity towards a solid polymer. Work is planned to determine the upgradability of the polymer.

Industrial Interest

A consortium of natural gas utilities is being organized to increase industrial participation in the program and to ensure relevance in evolving technologies for natural gas conversion. The objective is to provide leverage for Canadian companies, to ensure relevance of experimental programs by bringing together users and developers and to facilitate the transfer of these technologies.

Confidentiality agreements are being negotiated with companies interested in assessing an exciting spinoff from research initiated in the area of methane conversion with hydrogen deficient coreactants.

CONVERSION OF NATURAL GAS TO BLENDING STOCKS VIA INTERMEDIATES

Much research is being carried out on developing simpler, more efficient technologies for converting natural gas to liquid fuels. Current conversion routes involve the production of intermediates such as light olefins, synthesis gas or methanol. For instance, oxidative coupling and electric arc processes yield acetylene, ethylene and ethane as intermediates. Knowledge of the chemistry and catalytic conversion of these intermediates will be required to develop efficient integrated single-step technologies.

In-house research focused on the development of catalysts for the selective conversion of acetylene to BTX. Knowledge in this area will likely be very useful for the development of parallel systems such as the conversion of ethylene. The conversion of other intermediates such as methanol to gasoline has also been pursued.

Research is continuing on developing suitable catalysts for the selective production of diesel fuel from synthesis gas. A continuous, automated Fischer-Tropsch fixed-bed catalyst testing facility was completed and demonstrated in-house with continuous runs of up to two weeks yielding several hundred millilitres of liquid products. A catalyst research and development program has been initiated on the preparation and testing of new families of syngas conversion catalysts, e.g., shape-selective carbon and polymer supports with the goal of producing a high cetane diesel product from synthesis gas.

The most interesting catalysts obtained to date under contract were zeolites catalysts (CRIQ, Universite Laval, Guelph Chemical Lab.). In certain tests, as much as 70% of the liquid fraction produced was in the diesel range. However, the high liquid content was also accompanied by low liquid yields and high carbon dioxide levels.

DEVELOPMENT OF COPROCESSING AND COAL CONVERSION TECHNOLOGIES

OBJECTIVES

To investigate coal/heavy oil coprocessing technology; to establish a database for techno-economic evaluation; to transfer technology to industry.

ACHIEVEMENTS

The construction of a 18 kg/h coprocessing pilot plant was completed. This unit will be the largest and most sophisticated coprocessing unit in Canada.

The long-term operability of coprocessing has been demonstrated in a 300 kg/h continuous stirred tank reactor. Two hundred hours of operation were achieved without any instability or coke deposition.

COPROCESSING FUNDAMENTALS

Novel Catalyst Reactor System

Work on the novel catalyst system for coprocessing continued. Analysis of preliminary data revealed that the CSTR unit had limitations in terms of a maximum gas feed rate based on the heat removal capacity of the heat exchanger/condenser system used on the reactor outlet line. Design modifications were initiated to allow for the use of higher gas rates. It is planned to use some new externally supplied catalysts which were developed specifically for heavy feedstock upgrading.

High Severity Coprocessing

A project on high severity coprocessing of different feedstocks was started using oil samples supplied by U.O.P., Pittsburgh Energy Technology Centre and Ashland Oil. The CSTR was modified for the test program and data were generated at temperatures as high as 465°C. A new personal computer spreadsheet program was designed for data collection and analysis.

Coprocessing of Conventional Vacuum Residues

Preliminary coprocessing experiments conducted at ERL and by others indicated that heavy residues derived from conventional crudes are not as reactive as those from bitumens. Experiments were conducted to improve the reactivity of residues from conventional crudes by using different additives.

Coprocessing of High-Volatile Bituminous Coal

Two papers were published on the behaviour of bituminous coals under coprocessing conditions. The papers include test results from the coprocessing of two coals from Eastern Canada and one from the U.S., at a wide range of operating conditions. The formation of anisotropic solids was more noticeable for bituminous coals than for low-rank coals. This coke formation was related to the swelling and thermoplastic characteristics of the coals. The bituminous coals were found to be as reactive as or more reactive than low-rank coals at low temperatures. This was offset by their coking propensity at higher temperatures. The bituminous coals produced more naphtha, less heavy gas oil, less residual oils and more asphaltenes than low-rank coals.

Scanning Electron Microscopy of Coprocessing Residues

Residues from the coprocessing of low- and high-rank coals were examined by optical as well as electron scanning microscopy to study the origin of coke formation. Tentatively for low-rank coals, the coke originates from both the heavy oil and the coal whereas for high-rank coals essentially the coal portion of the feedstock contributes to the coke formation.

Effect of Additives on the Thermoplastic Properties of Bituminous Coals

The dilatation characteristics of five bituminous coals were examined. The swelling propensity of the coals was inhibited and in some cases eliminated by treating the coals with salts. The coprocessing behaviour of the untreated and treated coals was examined in a batch autoclave. It was found that the coprocessing of the salt-treated coals resulted in higher coal conversions and less coke formation than that of the untreated coals.

Solvent Coal Compatibility

Experiments were conducted on three low-rank coals and one high-rank coal in combination with two bitumen-derived and two petroleum-derived vacuum bottoms. The origin of vacuum bottoms has a significant effect on distillate yields and pitch conversions. Higher distillate yields were obtained from coprocessing the low-rank coals with bitumen-derived than with petroleum-derived vacuum bottoms. These observations were more pronounced when high-rank coal was coprocessed.

Characterization of Solvent Feedstocks for Coprocessing

Two bitumen-derived and two petroleum-derived vacuum resids were separated using HPLC into saturates, aromatics and polars. In general petroleum resids contain more saturates and less aromatics than bitumen-derived resids. The amount of transferable hydrogen was also determined for these resids using ^{13}C NMR and dehydrogenation methods.

According to the dehydrogenation method both bitumen and petroleum-derived resids contained the same amount of transferable hydrogen. However, the ^{13}C NMR method measured a higher amount of transferable hydrogen from both resids. Transferable hydrogen measured by the dehydrogenation method was correlated with coal conversion in these resids.

Low Pressure Viscometry

Experimental investigations into the rheology of coal-bitumen mixtures at atmospheric pressure and moderate temperatures using a Searle system (cup and rotor type) viscometer were completed. A master curve equation was developed for predicting the viscosity of coal-bitumen mixtures at any concentration and temperature (below 130°C) from the viscosity of bitumen only. The equation can be applied to coal-bitumen mixtures of greatly varied viscosity from less than 100 cp to more than 1 million cp.

FIMS Analysis of Coprocessing Distillates

Coprocessing distillates were separated into four fractions and subjected to detailed analysis using field ionization mass spectroscopy. The results will be correlated with the process performance.

Isotropic Mass Balance Measurement for Determination of Coal-Derived Liquid Contribution into Coprocessing Distillates

Products obtained from coprocessing coal with heavy oil/bitumen contain molecules originating from coal or heavy oil/bitumen. It is important to determine quantitatively the contribution of coal and heavy oil/bitumen in the production of distillates and residues. The objective was to use isotopic mass balance measurements to determine the contribution of coal-derived molecules to coprocessing distillates and residues.

Techno-Economic Study of CANMET Coprocessing Technology

A techno-economic feasibility study of small scale upgrading facilities that incorporate either CANMET hydrocracking or coprocessing was completed.

Physical and Chemical Changes in Treated Coals

The effect of additives on coal properties and on the coking propensity of coal/heavy oil slurries is being examined. The coking propensity was studied using a plastofrost apparatus. The coked material was also characterized by an optical microscope to determine the progressive rates of coke formation and the contribution to it of the coal and oil portions.

Mathematical Modelling of Coprocessing Kinetics

Experimental yield and conversion data were used to test several reaction networks in order to model the coprocessing reactions. The data best fitted a model involving a mixture of series and parallel reactions. The rate constants and activation energies were calculated.

Exploratory Investigation of Solid Removal from CANMET Coprocessing Residues

The ash content in coprocessing residues is normally so high that further utilization of the residues other than for straight combustion is difficult. Ash reduction from coprocessing residues, if successful, would allow recycle of the residues for further processing. Exploratory work is in progress.

Investigation of the Use of Spherical Oil Agglomeration in the Beneficiation of Low-Rank Canadian Coals as an Integral Part of CANMET Coprocessing Technology

High ash levels in low-rank Canadian coals can cause operational problems as well as reduce the overall process efficiency and the net liquid product yield. A novel method of ash reduction using pitch only instead of normal light oils was investigated and proved feasible. A patent application was filed.

PILOT PLANT CONSTRUCTION AND OPERATION

A contract was awarded to develop, construct and install a pilot plant electronic instrumentation system.

CATALYST DEVELOPMENT

Process Additive Research

A series of coprocessing catalysts supported on hydrous titanates was compared with the CANMET additive at high severity conditions in terms of coal conversions, oil yield and content of heteroatoms in distillates. The tests which were performed in a semi-continuous reactor system, showed advantages in using the titanates because of their wide range of pore diameters enhancing diffusion of hydrocarbon molecules within the pores, their appropriate acid site density for proper solvent enrichment for hydrogen transfer capacity, and their large number of active sites per surface area. Highly dispersed catalysts, which were prepared from emulsions, were tested to assess their potential use in coprocessing.

Low Temperature Mössbauer Spectroscopy of Tin Catalysts

Tin-containing catalysts, which were prepared and tested at ERL, were characterized by low temperature Mössbauer spectroscopy under contract to obtain quantitative information on the oxidation state of the catalyst sites. Scanning electron microscopy and X-ray diffraction gave additional information on the morphology and the structure of the titanate support.

COAL LIQUEFACTION

Catalytic Two-stage Liquefaction of Nova Scotia Coals

Fourteen catalytic two-stage experiments were conducted using hydrogenated coal-derived oil as reduction solvent. Experiments were carried out under contract on Lingan Harbour, Prince Hub and Donkin Harbour seam coals from Nova Scotia to assess coal reactivity and the effects of operating conditions and catalyst age on product yields. High coal conversions were achieved, however, the levels of asphaltenes and preasphaltenes were high as well.

Flash Hydropyrolysis of Prince Mine Coal

Earlier it was demonstrated that Prince mine bituminous caking coal could be pyrolyzed continuously if the feed were mixed with appropriate diluents. The use of subbituminous coal fine as the diluent was tested under contract.

Characterization of Solid Residues from Coal-Oil Coprocessing

Samples of coal feedstocks and solid residues from coal-oil coprocessing were analyzed petrographically to determine the coke yield and coal conversion. Micro-FTIR spectroscopy was used to support the petrographic assignments and to analyze low severity coprocessing conditions to establish the origin of bituminous intermediates in these residues. SEM/EDAX analysis of mineral matter in bituminous coal coprocessing residues was also used to assign the genesis of the residue.

FLUIDIZED BED COMBUSTION

OBJECTIVE

To expedite the application of fluidized bed combustion technology in the utilization of low-grade fuels.

ACHIEVEMENTS

A bench-scale method was developed for evaluating various minerals as sulphur-capture agents in fluidized bed combustion systems. A CANMET report describing the test method and the results of tests on about 30 Canadian limestones is in press.

The bubbling-bed pilot plant, which was designed for coal, has been modified to burn liquid bitumen and heavy oil residues. Efficient combustion of these fuels was achieved with low acid gas emissions.

BUBBLING FBC PILOT PLANT

The CCRL Mark II fluidized bed combustor has been in operation since 1980. It has been used to establish combustion performance and emission data for a variety of fuels; information which is required by designers of fullscale systems. Much of the work has been in direct support of the CFB Summerside demonstration described later.

To date most of the work has been on coal or similar solid fuels, however, some effort has been devoted to heavy liquid fuels to address an antici-pated need for disposal of pitch residues from oil sands/heavy oil upgrading. Combustion trials were carried out on Bunker C residual oil, raw bitumen and CANMET pitch. It has been found that reliable fuel handling, that is heating, pumping and injecting into the bed, presents more technical problems than achieving good combustion and low emissions.

CIRCULATING FBC PILOT PLANT

A contract was awarded to design a circulating FBC pilot plant. The combustor is 400 mm ID, 7 m high, and fires about 100 kg/h of coal. The assembly, building modifications and erection of support steel are now underway and completion is scheduled for March 1988.

COAL REACTIVITY

A bench-scale FBC apparatus and an empirical procedure whereby the reactivity of coals and other fuels can be ranked were developed. The apparatus, commissioned in 1982, is a small, externally-heated, batch-fed fluidized bed combustor with a sophisticated flue gas analysis system. Current efforts are concentrated on elucidation of FBC reaction mechanisms to facilitate mathematical modelling. The apparatus has been modified to permit measurement of the amount of volatiles evolved, and the devolatilization time. Effects of attrition and fragmentation on the combustion

process are also being studied. Fuel particle characteristics will be measured at various stages of combustion as part of the process of verifying, by experiment, various models which have been proposed.

SO_2 SORBENT REACTIVITY

In 1982 CANMET's Mineral Sciences Laboratories (MSL), in cooperation with CCRL, undertook to develop a database of the sulphation capacities of various Canadian limestones likely to be utilized in fluidized bed combustion. MSL developed a bench-scale apparatus and procedure in which a simulated flue gas containing SO_2 is passed through an electrically heated fluidized bed of the test limestone. This approach has been adopted by the Risoe National Laboratories of Denmark.

The fluidized bed test apparatus is being used to evaluate agglomerates of coal, oil and limestone prepared by the Division of Chemistry, National Research Council. This has potential application in the upgrading of coal and the utilization of heavy oil upgrading. Also, a TGA system is being developed to determine the reactivity of finely divided limestone and will be used to develop the necessary sulphation parameters for mathematical modelling of sulphur capture.

BENCH-SCALE CIRCULATING FBC

Although circulating FBC is one of the most promising technologies for the utilization of residues such as coke and pitch from upgrading of tar sands and heavy oil, boilers may suffer severe corrosion due to the high concentrations of alkali and vanadium. To establish the fate of corrosive agents in an FBC environment, MSL has built a pilot-scale circulating FBC (50 kW, 100 mm diam) and to date has carried out two major series of combustion tests.

A method in which microwave digestion employing aqua regia and hydrofluoric acid was developed to achieve complete solution of inorganic components. The acid-insoluble fraction then represents unburned carbon, whereas the major and trace elements in the acid-soluble fraction can be determined by inductively-coupled plasma spectrometry.

MSL is verifying the acid extraction technique by developing a thermogravimetric differential thermal analysis technique which measures carbon, calcium sulphate and other major constituents. This is supplemented with X-ray diffraction and scanning electron microscopy.

QUEEN'S UNIVERSITY - BUBBLING FLUIDIZED BED COMBUSTION

Queen's University carried out the following work under contract:

- mathematical modelling of bubbling bed FBC
- combustion of petroleum coke from a refinery in Saskatchewan
- combustion of Mount Klappan anthracite

- combustion of Lingan coal with Irish Cove limestone as sulphur sorbent

- combustion of Highvale coal

- mechanisms of fluidized bed combustion.

In April 1987 Queen's University began work under another contract to develop a three-dimensional mathematical model of bubbling FBC systems.

UNIVERSITY OF BRITISH COLUMBIA - CIRCULATING FLUIDIZED BED COMBUSTION

Under contract UBC provided circulating FBC combustion data for three coals, two forms of wood waste, and two pitch residues from heavy oil upgrading. The results were used to develop ash disposal procedures for large boilers such as the Chatham circulating FBC demonstration.

A follow-on contract is addressing additional coals, pitch, and black liquor from the pulp and paper industry. It also addresses fundamental studies such as the mechanisms of the sulphation reaction, and the development of a first generation mathematical model for circulating FBC.

DEARBORN ENVIRONMENTAL CONSULTANTS - APPLICATION OF CIRCULATING FBC RESIDUES TO CONCRETE

A contract was awarded to explore the potential of making concrete from the residues generated by the Chatham circulating FBC demonstration.

MONENCO CONSULTANTS LTD. - ENGINEERING EVALUATION OF FLUIDIZED BED BOILER DEMONSTRATION PLANT AT CFB SUMMERSIDE, P.E.I.

A contract was awarded to prepare a comprehensive report documenting the operating history of Canada's first full-scale FBC heating plant at CFB Summerside, PEI. Special attention was given to the important issue of boiler tube erosion. The final report has been distributed and forms a major part of the documentation on the Summerside demonstration.

STAKE TECHNOLOGY LTD. - COAL FEEDING TRAILS WITH THE STAKE CO-AX PRESS

Some years ago Stake Technology Ltd. developed a biomass conversion process, a key component of which was a patented feeder capable of injecting material such as wood waste into a high pressure reactor. It appeared that the feeder, known as the CO-AX press, might be useful for charging coal into pressurized gasifiers and fluidized bed combustors. CANMET accordingly sponsored contracts in 1980 and 1984, which proved the validity of the concept by means of bench scale tests that correlated the gas permeability of coal plugs to conditions of pressure, thickness, coal size and moisture content.

A contract was awarded to evaluate a full-scale CO-AX press. The contractor installed a machine at ERL and operated it, while ERL provided the test coal. Both parties worked together to measure the permeability of plugs formed by the press.

It was found that the discharge configuration used for biomass did not form good plugs with coal. It has been demonstrated that the CO-AX press can be adapted to high pressure coal feeding applications.

NEW BRUNSWICK RESEARCH AND PRODUCTIVITY COUNCIL (NBRPC)

New Brunswick coal, oil shale and limestone are being tested in the pilot-scale 125 mm diam. circulating FBC at NBRPC. The objectives are to calibrate its performance against the full-scale unit at Chatham, then to conduct a series of parametric tests to predict full-scale performance and thus reduce full-scale testwork.

NEW BRUNSWICK ELECTRIC POWER COMMISSION (NBEPC)

The Chatham circulating FBC demonstration consists of a 22 MWe utility boiler funded by EMR but built and operated by NBEPC. It wishes to explore the potential application of this technology to New Brunswick feedstocks, particularly high-sulphur Minto coal. Thus NBEPC proposed to cost-share with CANMET a program of tests to optimize sulphur capture and sorbent utilization. Two New Brunswick limestones will be tested.

FBC HEATING PLANT AT CFB SUMMERSIDE

EMR's first major demonstration of FBC technology was the heating plant at CFB Summerside. It consists of two bubbling bed boilers, each rated at 18 t/h of steam, designed to burn high sulphur Eastern Canadian coal with 80% sulphur capture.

In February 1986 a contractor for the U.S. Environmental Protection Agency (EPA) conducted a 4-week program of emissions testing at the Summerside plant. It was demonstrated that with a Ca/S ratio of about 4, 90% sulphur capture could be routinely achieved, firing a coal containing 5.5% S. The data from this program were ultimately used by EPA to set new source performance standards for industrial coal-fired boilers.

The 1987/88 heating season to date has been the most satisfactory. There is normally only one boiler in service, and it has occasionally met load demands up to 150% of maximum capacity rating. By March 1, 1988 Boiler 1 had operated an additional 1100 h, and Boiler 2 an additional 3400 h.

EMR and DND are now considering a request by the Electric Power Research Institute (EPRI) of the United States to install tube specimens in the Summerside boilers, as part of a comprehensive program to study corrosion/erosion in fluidized bed boilers.

Circulating FBC Utility Boiler Demonstration at Chatham, N.B.

EMR's 20 MWe circulating FBC utility boiler at Chatham (managed by NBEPC) was commissioned and under CANMET's Energy Conversion Cost Shared Program three proposals were accepted for work supporting the Chatham demonstration and contracts are now in place.

In January 1988 a cost-recovery project to study the FBC combustion of petroleum coke was successfully completed for a foreign client.

IEA Agreement on AFBC

In 1980, under the auspices of the International Energy Agency (IEA), nine nations including Canada signed the "Implementing Agreement for Cooperation in the Field of Atmospheric Fluidized Bed Combustion in Industrial or District Heating Boilers". Canada's representation and participating projects are all from ERL.

The main function of the agreement is to share information on the specific "participating projects" thus on an international scale, duplication of effort is avoided. However, a joint project has been undertaken to develop a mathematical model of FBC as a future tool for designing boilers. Work is proceeding in Canada, Denmark, Sweden, the Netherlands and the Federal Republic of Germany, using as a basis a model developed at Queen's University under CANMET sponsorship.

PULVERIZED COAL COMBUSTION

OBJECTIVE

To develop a database on combustion performance and emission characteristics of Canadian coals destined for power generation.

ACHIEVEMENTS

A computer program has been developed to predict combustion and heat transfer conditions for high-and-low volatile coals in cylindrical furnaces. The model allows the number and cost of combustion tests to be reduced by a factor of 3.

THERMAL COAL FOR ELECTRICITY GENERATION

Eleven coal combustion evaluations were performed in ERL's pulverized coal-fired pilot-scale utility boiler. Six of these were concerned with an ongoing in-house project to determine the effect of blending, residence time and coal beneficiation on coal combustion efficiency. Five were to determine the burning properties of coal-liquid mixtures in the utility boiler using a burner/swirl generator developed at ERL.

In-house combustion investigations on behalf of the International Energy Agency (IEA) are continuing. Two reports have been issued and a third summarizing all of the IEA tests is in preparation. The first edition of a reference cataloguing the combustion and emission characteristics of various Canadian coals investigated from 1973 to 1983 will be published soon.

COAL AS A SUBSTITUTE FOR OIL IN INDUSTRY

ERL's tunnel furnace is designed to fire pulverized coal, light and heavy fuel oil, natural gas, biomass products and coal-liquid mixtures at an input rate of about 2 GJ/h. Combustion and heat transfer characteristics of coals were investigated in ERL's tunnel furnace, then compared with fuel oil burned under similar aerodynamic conditions.

Gas probes are used to measure a range of parameters which define spatial temperature, flow and concentration profiles within the furnace atmosphere together with emission levels at the furnace exit. Heat transfer, both convective and radiative, can be measured along the length of the flame. The furnace can also be partially refractory-lined to simulate a number of industrial configurations using various feeds and comparative burner assemblies can be studied.

COMBUSTION OF HEAVY OIL RESIDUES

ERL's tunnel furnace was used to develop procedures and to design, fabricate and optimize pilot-scale equipment that is capable of handling and burning highly viscous residues (pitch). This project was funded by the Alberta Oil Sands Technology and Research Authority (AOSTRA).

LASER DIAGNOSTIC TECHNIQUES FOR FOSSIL FUEL FLAMES

A significant effort is underway to develop non-intrusive diagnostic techniques to replace conventional methods of measuring flames.

Optical diagnostic methods will eliminate the inherent errors associated with conventional methods and provide a better quality of measurement. The coherent anti-Stokes Raman scattering (CARS) technique can be used to measure temperature and species concentration in a combustion environment. The laser Schlieren technique is used to visualize the phenomena that occur in flames. The laser doppler anemometry (LDA) technique is envisioned for measuring gas velocity and particle size distribution.

Improvements have been made to the hardware and software to improve the technique's dependability and accuracy. A calibration test rig was installed to ensure long term accuracy and consistency of the CARS measurements.

An improved dye laser was installed in the CARS optical arrangement. It is now possible to visually compare theoretical and experimental CARS spectra and to identify and diagnose "bad" CARS experiments.

NEW COAL BASED FUELS

OBJECTIVE

To decrease the consumption of premium liquid and gaseous fuels in Canadian industrial and utility applications by developing and evaluating new coal based fuel alternatives.

ACHIEVEMENTS

An industrial coal water fuel burner was developed using a National Research Council atomizer design. Novel features are a dual fuel (oil or coal water mixture) capability and a capacity of 30-80 GJ/h with excellent flame stability and no nozzle wear.

MARITIME ELECTRIC GENERATING STATION

Under an agreement between EMR Canada, NB Electric Power Commission and the Cape Breton Development Corporation a coal water fuel (CWF) and burner demonstration was successfully carried out at Chatham, NB in generating facilities originally designed to burn pulverized coal. Under a new agreement and as a continuation of Canada's Coal Utilization Program, Maritime Electric Company Limited, became a participant in a demonstration to assess the economics, environmental acceptability and effects on boiler performance of burning CWF in a compact oil-fired utility boiler at Charlottetown, PEI.

The boiler used in this demonstration is a forced draft, pressurized Stirling design unit rated at 20 MWe with a steam output of 86 000 kg/h. The CWF manufactured by the Cape Breton Development Corporation, contains approximately 30% water and is made from low sulphur coal which has been beneficiated to substantially reduce the ash and sulphur content in the finished product.

ERL has provided technical assistance to the demonstration and has been involved in burner development which addresses wear resistance, good atomization and carbon conversion through better atomizer design and combustion air and fuel mixing. A burner prototype, which was developed at Chatham, was tested during the earlier Charlottetown demonstration and had the following advantages:

- improved fuel/air mixing leading to carbon conversion efficiencies of 98%;
- wear resistent atomizer resulting in longer service life;
- dual-fuel capability (No. 6 fuel oil/CWF) using the same atomizer which eliminates the need for gun replacement when fuels are switched.

The CANMET burner showed excellent operability and was tested over 30-80 GJ/h with design capacity of 55 GJ/h. The unit will be converted to five CANMET burners during the summer of 1988, and comparative performance data will be obtained from commercial burners which use CWF and oil.

Techniques developed from the Chatham and Charlottetown CWF demonstrations will enable industry and electric utilities to consider, with some degree of confidence, the potential this new technology may offer as a means of economically replacing imported oil with a domestically refined coal product in an environmentally acceptable manner.

MINAS BASIN PULP AND POWER CWF CONVERSION PROJECT

This project involves the conversion of an oil-fired package boiler to CWF. The application is a single burner, load following, boiler conversion which will provide steam for pulp production on a commercial basis for two years. The burner installation in the spring of 1988 will be followed by commissioning trials and commercial operation. Participants are NS Mines and Energy, CANMET, and CBDC.

This application targets not only the pulp and paper industry, but also other small to medium industries that currently raise process steam by oil firing. The proposed demonstration addresses a number of technical risks which stem from technical uncertainties associated with an ability to stably burn CWF in an environment subjected to frequent changes in the boiler load, and with extremely high wall heat extraction rates. The critical issue is the ability to identify and develop boiler and burner hardware modifications and control systems that can circumvent these difficulties and the associated changes in the CWF make-up (chemicals, coal feedstock) which are able to improve the combustion characteristics of the fuel. The latter presents significant risks to the CWF manufacturer and potential benefits that may enhance the long term competitiveness of the fuel through cheaper manufacturing costs.

This program presents an opportunity to evaluate the long term effects of CWF combustion in a boiler and the erosion of burner and peripheral equipment that remains untested in the short term demonstrations described previously. Elements of technology transfer involving the testing of a new high efficiency CWF burner and atomizer developed by CANMET and NRC are also linked to this project.

SPRAY QUALITY AND ATOMIZER ASSESSMENT

The atomization characteristics of CWF and the performance of generic CWF atomizers were evaluated under contract at the Nova Scotia Research Foundation Corporation. The project was funded by the Canada-Nova Scotia Oil Substitution Agreement and was carried out under the technical supervision of EMR/CANMET. The spray test facility has proven to be a very valuable link in providing data in support of the ongoing CWF demonstration program in Charlottetown, PEI, and in the optimization of the CWF production and fuel preparation techniques at the CWF production plant operated by the Cape Breton Development Corporation plant in Sydney, NS.

Micronized Coal Study

Superfine coal, when properly utilized, should improve ignition, carbon burnout and furnace performance relative to a standard coal grind. A technical and economic assessment of micronized coal mills and the state of micronized technology was undertaken on behalf of CANMET by Stone and Webster Canada Limited.

METALLURGICAL FUELS

OBJECTIVES

To develop metallurgical fuel technologies that extend energy resources, improve coke quality and conserve energy.

To determine coking characteristics of Canadian coals in support of resource evaluation, export markets, and the Canadian steel industry.

ACHIEVEMENTS

Technical assistance has been given to the Canadian coal industry, especially through the Canadian Carbonization Research Association, on defining thermal/metallurgical coal interfaces during mining and on wash plant control to ensure the quality of cokes from Western Canadian coals.

A technical review entitled "Coals in Canada: Resources, Research and Utilization" was published. This document, which has been given good international exposure is a valuable marketing tool for Canadian coking coals.

FUELS AND CARBON FOR METALLURGICAL PROCESSES

An R&D program on pulverized and granular coal injection was initiated and a literature study was completed. Analysis of data from 56 operating furnaces confirmed that low volatile matter (VM) coal is beneficial for high coke replacement. Also, an empirical formula, which determines coke replacement as a function of coal rate, blast temperature, and coal-to-air ratio has been derived. Many Canadian coals appear to be suitable for tuyère injection. Industrially, applied mechanical systems of coal distribution and injection have been described and critiqued. It has been found that VM content is not the only criterion to evaluate coal combustibility and other factors such as tar content and char micro-structure should be considered.

Work on CANMET hydrocracked resid has shown a relationship between carbon aromaticity and the nature of coke formed on heating. This finding is significant for industrial application of CANMET resid in the production of electrodes for the aluminum industry. In addition, a detailed gas chromatographic study of CANMET resid has shown this material contains only a very small quantity of polynuclear aromatic hydrocarbons.

CONVENTIONAL COKEMAKING

ERL's technical-scale coke ovens are extensively used by the coal and steel industry to evaluate the coking properties of coking coals and blends having potential commercial applications. These coke oven trials are often supplemented by small-scale tests to measure dilatation and by laboratory analyses to determine the chemical, rheological and petrographic properties of coal and coke. Coal and steel companies rely on these facilities to evaluate and market their coal resources and to evaluate and select the best combination of coals and blends for purchase and operating purposes.

CANMET decided recently to consolidate the carbonization activities at the Bells Corners Complex. The moveable wall oven at Devon (CRL) will be relocated to ERL.

GASIFICATION

OBJECTIVE

To evaluate and optimize coal gasification for the clean production of electricity.

ACHIEVEMENTS

Several industrial waste solids have been identified as sorbents for hot gas cleanup before combustion of the gas in integrated gasification combined cycle units. These materials are much cheaper and more efficient than the proprietary compounds used now.

HOT GAS CLEAN-UP OF GASIFICATION PRODUCTS

Several low cost solids disposed from metallurgical and aluminum industries have been successfully tested both in sulphidation and regeneration modes.

GASIFICATION OF NON-REACTIVE FEEDSTOCKS

An entrained bed gasification system is being constructed to characterize non-reactive feedstocks under conditions of the most advanced gasification processes. The evaluation of gasification reactivities of Canadian coals is continuing.

LIQUID PRODUCTION POTENTIAL OF CANADIAN OIL SHALES

R&D activities on oil shales in Canada and other parts of the world are being monitored and a data file is updated continuously.

COMBUSTION TECHNOLOGIES FOR POLLUTION ABATEMENT

OBJECTIVE

To reduce the production of acid rain precursors in combustion processes.

ACHIEVEMENTS

In-furnace techniques have been demonstrated for the control of acid gas emissions from a 150 MWe lignite-fired boiler. The project was co-funded by three government agencies and three industrial participants. The results of this work were used in the design of the new 300 MWe boilers being built for the Shand generating station in Saskatchewan.

ABATEMENT OF COMBUSTION SOURCE EMISSIONS

The increasingly stringent protocols under consideration for controlling emissions from utility and industrial boilers in Japan, North America and western Europe have resulted in an urgent need for economic, reliable pollution abatement technology before 1994. In response CANMET/ERL is participating in a number of projects in collaboration with industry, provincial government agencies and foreign organizations to accelerate the demonstration of various techniques for in-furnace suppression of acid rain emissions. Most of this activity is directed at existing installations because only a few new Canadian thermal power plants will be built before the mid-1990's.

International Energy Agency Low NO_x Combustion Agreement

Under an IEA sponsored project, Canada, Denmark, Sweden and the USA co-funded a bench-scale study in which 50 world coals, including nine from Canada, were characterized for NO_x generation and reduction potential. It was found that much of the nitrogen released as volatile matter can be transformed to N_2 rather than NO and that the conversion of fuel nitrogen to NO can be reduced from about 42% to 14% by providing a stoichiometry of less than 0.7 in the primary flame zone. This research led to the design of a 20 MWt, prototype wall-fired burner incorporating multiple air staging for NO control, with limestone injection through tertiary air ports for SO_2 control. Burner tests with a high-volatile Canadian coal at 120% total air showed that NO and SO_2 emissions could be reduced by over 70% and 50% respectively with optimized air staging and a calcium/sulphur ratio of 3. The coal contained 2.6% sulphur, 1.2% total nitrogen and 0.7% volatile nitrogen. Calcium utilization was about 20% of the input.

CFB Gagetown Demonstration

The concepts developed in the IEA program led to collaborative full-scale demonstrations of in-furnace NO_x/SO_2 control technologies in Denmark, Sweden and Canada. Three wall-fired boilers rated at 450, 150 and 20 MWt, are being evaluated for NO_x and SO_2 reductions using a common test plan and the same data reduction procedures, so that key parameters for the different boiler and burner sizes can be comparatively evaluated. Canada's demonstration is being conducted on a 20 MWt high-temperature, hot water generator at Gagetown, New Brunswick. The generator is equipped with two low NO_x/SO_x burners, designed to burn a high-volatile bituminous coal containing up to 3% sulphur. Field trials have yielded reductions in acid rain emissions varying from about 65% at one-half load to 45% at full load an an increase in boiler efficiency of about 3% relative to the original burner installation. The results of the joint program will be exchanged among member countries.

Boundary Dam Demonstration

In another demonstration, initiated by industry with government support, a 150 MWe lignite-fired boiler with a tangential burner array was modified to determine whether the normally low emissions of NO_x and SO_2 from this

unit could be further reduced by burner air staging and upper furnace sorbent injection. The boiler modifications were designed to provide a lower furnace stoichiometry of about 1.0, an air rich zone above the fireball and the injection of sorbent into different temperature zones of the upper furnace. At full load with 3% O_2, NO_x and SO_2 levels each decreased by over 30% when calcium hydroxide was added to produce an input Ca/S ratio of 3.

These trials also identified a critical need for future research to elucidate the role of inherent sodium and calcium in ash on sulphur capture and to develop improved computer models for predicting local furnace conditions from coal properties, boiler heat transfer specifications and burner input data. The results generated from this demonstration were used to validate a three-dimensional furnace model for optimizing the various parameters for minimizing NO and SO_2 from this low-sulphur coal.

Canadian Electrical Association Advisory Panel

ERL serves on a panel of experts comprising utility members, EMR Coal Division and Environment Canada to advise the CEA on research priorities and technology options for controlling emissions from existing and future utility boilers. The panel also evaluates R&D proposals submitted to government departments and the CEA that relate to the clean use of fuel for electricity and the applicability of foreign technology to Canadian utility operations.

Other Activities

At the request of the CEA, ERL provided technical monitors for two contracts dealing with the combustion performance of a high-sulphur coal in the TransAlta slagging combustor, and the mathematical modelling of the Boundary Dam steam generator used in the sulphur capture and low NO_x trials with lignite.

ERL was also asked to participate on a peer review panel to monitor a US Environmental Protection Agency contract involving the use of natural gas reburning for NO_x control in three coal-fired utility boilers.

CONSERVATION IN RESIDENTIAL, COMMERCIAL AND INDUSTRIAL SYSTEMS

OBJECTIVE

To increase fuel efficiency in residential, commercial and industrial applications, to utilize alternative renewable fuels and to ensure safe and environmentally acceptable operation.

ACHIEVEMENTS

A new high-efficiency gas-fired water heater has been designed. Potential energy savings are 30-40%.

A new technique has been developed for measuring the aromatic content of refinery streams. This allows oil companies to produce high quality heating fuel while using the crude oil most efficiently.

SPACE HEATING - OIL AND GAS

Under contract MARBEK Resource Consultants Ltd. conducted an evaluation of CANMET's Fossil Fuel Heating Program. The study concluded that "this program provided very substantial economic benefits to Canadian consumers, heating equipment manufacturers and other organizations. It is an excellent model for government involvement in industrial R&D and product development; the key to the program's overall influence, leadership and acceptance is the combination of technical capability and unbiased approach to the technologies involved".

The major emphasis is directed to the evolution of technology and strategies to replace oil with natural gas as the primary space and water heating fuel. By developing retrofit devices and new designs of combustion systems to improve burner/furnace efficiency and reduce potential unsafe operating conditions with present systems and more energy efficient housing, efficiency improvements of 20 to 40% are possible on gas. By using substitute and degraded liquid fuels, additional oil may be available for the transportation sector.

In-house R&D on new technologies for space and water heating is ongoing with additional projects in the field, mainly by contract. Development of specific advanced technologies is also carried out by contract to industry. Seasonal performance experimental procedures are being developed and new designs produced, with the results transmitted to standards writing agencies, testing laboratories, manufacturers and government agencies through standards committees, published papers, seminars, associations; e.g., Canadian Standards Association, Canadian Gas Association, Canadian Wood Energy Institute, Ontario Petroleum Association and Canadian Home Builders Association and through close cooperation with individual manufacturers and utilities. Liaison is also maintained with US developments, particularly related to environmental concerns and alternative technologies.

The retrofit condensing furnace, developed by CCRL and Clare Brothers, which can augment the efficiency of the existing gas furnace in the home by 20-30%, has now been placed on the market in both Canada and the US by Clare. There is additional interest in this device because it offers the potential to cure spillage and draft problems from conventional gas furnaces in tighter houses while giving major energy savings.

Preliminary testing has been carried out on two advanced oil-fired furnaces. The first is a condensing furnace equipped with a high quality stainless steel heat exchanger to prevent corrosion. Steady state and seasonal efficiencies for this unit are over 90%, but there is some concern for potential problems with long term operation. Further testing should determine the unit's durability and corrosion resistance. The second is a prototype high efficiency non-condensing design which operates fairly near

the dew point. Preliminary results indicate that it should run at a seasonal efficiency above 85% while avoiding the problems and costs of condensing appliances.

Long term cyclic testing of a second generation prototype plastic condensing furnace using a polyethylene/polypropylene co-polymer is continuing. The unit operated for over one year without any indications of deterioration in either performance or material integrity.

Other studies have been carried out on a flue gas heat extractor for condensate evaluation, a prototype combined space and water heating unit and on the thermal performance of various flue pipe designs.

Technical support has also been given to a number of research and standards writing organizations concerned with the safe venting of combustion appliances and with new standards for chimneys and fireplaces including guidelines for appropriate flue sizing.

Increased use of Canadian distillate fuel oils processed from synthetic crudes has caused concern for deteriorated performance. Physical and chemical properties of middle distillates can significantly influence the combustion characteristics of the heating appliance. In cooperation with the oil industry, a series of experiments has been carried out to examine the effect of fuel quality degradation. Combustion characteristics such as burner ignition behaviour, emissions of incomplete combustion products, furnace temperatures, efficiencies and excess air levels are obtained from controlled laboratory experiments, simulating a real-life home environment.

Analyzing the experimental results shows that while the combustion characteristics are influenced by interacting physical-chemical properties, fuel aromaticity and viscosity show a strong correlation with particulate and gaseous emissions. In particular, correlation equations between fuel properties and emissions characteristics have been developed at CCRL. Using these equations, one can predict cold start transient emissions of particulates, carbon monoxide and hydrocarbons based on fuel properties of viscosity, aniline point, distillation range and hydrogen content. Additional work is being carried out to relate burner ignition performance and critical emission levels to predict overall burner performance, solely from fuel properties. In support of this work a computer program, written in C language, is being developed to assist in the calculations and provide a full understanding of the related multilinear regression analysis. Once the correlation equations are tested to satisfaction, the technology will be transferred to the Canadian oil industry.

In response to the oil industry's need for an accurate technique to measure aromatics in refinery operation, a new measurement technique has been developed. Supercritical fluid chromatography with flame ionization detection is applied for separation and detection of saturates and aromatics in middle distillate fuels. Analysis time is reduced by a factor of 12 over the commonly used FIA, with much greater accuracy. It is particularly suitable for heavier distillates produced from oil sands-derived crudes and low cost blends containing high boiling fractions.

Severe problems may occur with the venting of combustion appliances, in both new and existing housing. In cooperation with Canada Mortgage and Housing Corporation, the operational characteristics of fossil fuel- and wood-fired appliances are examined in relation to the chimneys they feed. Both steady state and cycling characteristics are important. Changes in fuel, the use of mixed energy sources and improvements in efficiency have all affected the chimney environment. Modifications to the venting system, such as relining and repair, the use of double walled flue pipe, or modifications to the furnace/burner system such as the retrofit induced draft fan system described previously may improve the venting performance.

INDUSTRIAL ENERGY CONSERVATION

This program, previously called ENERSOLVE, is concerned with increasing the efficiency of utilization and reduction of consumption of fuel in industrial processes. Much of the present industrial equipment, particularly if more than 10 years old, may not be operating or even operable at maximum attainable efficiency of fuel use. Scope exists to technically upgrade most installations to attain greater fuel economy. The program is intended to support a limited number of specific studies on retrofit of combustion systems in a variety of industrial sector and regions of Canada. By this means, a fully documented capability for energy conservation will be formulated by the performers, enabling them to subsequently and privately offer such services to industry in general, perhaps even with a guaranteed payback.

During the course of the ENERSOLVE studies, it has been found that Canadian industry often uses rigid procedures developed for steam-raising boilers with specific fuels to determine performance without realizing the simplifications or complexities required for other industrial processes or for different fuels. It has become apparent that there is a significant lack of knowledge of the fundamentals of combustion system analysis and of the major potential benefits that may accrue from improvements to that system. It is important that the general principles, industrial results and the fact that there are now Canadian consultants who are developing the skills to provide such a service to industry should be made widely known.

The potential for energy savings by recovery of latent heat in the flue gas from industrial processes and commercial boilers has scarcely been realized in Canada. ERL has carried out a number of studies to show the potential in specific applications. A study is presently being carried out to determine the potential suitability for a retrofit flue gas condensing system for gas-fired heavy oil recovery boilers. In addition, various IERD and ENERDEMO programs for EMR have been advised on the technical aspects of industrial and commercial condensing heat recovery systems. One specific example was the technical inspection of a direct contact heat exchanger unit installed in a hospital in southern Ontario. Certain potential problems have been identified and ERL is working with the hospital to attempt to resolve them.

ENERGY SYSTEMS

While some technologies for energy use or conversion have achieved levels of efficiency that approach practical limits, further improvements are possible through the development and application of integrated energy systems. Furthermore, the development of such a system may permit the cost effective use of energy forms that might otherwise not be suitable. Through the assembly of heat loads by a district heating system, it may be possible to use locally available energy resources including waste heat or low cost solid fuels.

Within ERL, this work is primarily one of contract research, with all work closely controlled through interdepartmental and private sector committees. Coordinating committees ensure that there is no duplication of effort, that the work done is of as wide interest as possible and that the information may be transferred to industry for application as soon as possible.

Documentation of the Charlottetown district heating systems demonstrates the economic benefits of being able to use local woodchips instead of imported oil, and the techniques required to assemble a large heating load. The installation has been so successful that the existing standby Maritime Electric power plant may be converted to a cogeneration station producing competitive electricity and heat.

A comparative analysis of steam and hot water for district heating has been completed. It demonstrates for space heating loads hot water technology is much more cost effective and efficient. It also shows that conversions of existing steam systems to hot water are also economically feasible.

Under ERL's leadership, a Canadian group has been formed to develop a joint research program on advanced fluids for district heating and cooling.

Ice and slurry technologies offer the potential for district cooling systems, using off peak power, either on a seasonal basis with ground storage, or on a daily basis with a local storage tower. A number of potential projects in this area are presently being considered.

A district heating simulation computer model has been upgraded and is being used to examine and potentially optimize the system at the Bells Corners Complex.

The heat pump program has focused on the development of high temperature units for industrial application, the development or application of new working fluids for a variety of applications and the improved cost-effectiveness of efficient ground source technology. IEA participation has been of major benefit to this program. Canadian manufacturers and research organizations are heavily involved in all aspects of our program. One of the world's first vapour recompression steam generating heat pumps has been commissioned at the National Research Council, based on a design developed in this program. Followup applications with the pulp and paper industry are anticipated.

Another program deals with the development of new non-azeotropic fluid mixtures to be used as chlorofluorocarbon substitutes for heat transfer fluids in heat pumps.

New copper coil vertical heat exchangers have been developed for ground source heat pumps. Two particular demonstrations of this technology are in a greenhouse in Ontario and under the building foundation of a firestation in the Yukon to protect the permafrost while heating the building.

A hybrid electric/gas heat pump has been installed at ERL. Tests are being carried out and efficiency for both heating and cooling is being compared with conventional systems.

BIOMASS FUELS FOR RESIDENTIAL AND INDUSTRIAL UTILIZATION

OBJECTIVE

To increase the efficient utilization of combustible renewable resources.

ACHIEVEMENTS

Field trials in Whitehorse, YT, showed that increased efficiencies and reduced pollution from existing wood stoves were achievable by using add-on catalysts and improved stove designs.

A novel wood-waste combustion system was evaluated for technical reliability. This system was for a co-generation plant at Timmins, Ontario, and the CANMET report was used to support a request for a $13 million bank loan by Northland Power Co. This work was done on a cost recovery basis.

RESIDENTIAL WOOD COMBUSTION

Wood stoves have been shown to be an efficient and often cheap way to heat a house. However, often significant amounts of incomplete combustion products can be produced, resulting in a potential fire safety hazard if deposited in the chimney in the form of creosote, or in a severe air pollution problem, in areas of poor fumigation. ERL efforts have been directed towards changing the design of these appliances in order to improve combustion performance and by generating techniques by which the performance can be effectively measured.

In addition to carrying out further work to finalize these standards, ERL is now carrying out an experimental program to extend the standard to cover central heating appliances. Other efforts are primarily geared to develop techniques or strategies to improve the performance of existing appliances in the field, particularly for areas such as Whitehorse, where a severe air pollution problem can be traced directly to the use of wood burning appliances.

Work has been proceeding on techniques to improve the performance of existing appliances, and technical support is being given to a long term field study of appliance performance in homes in Vermont and New York State, sponsored by the Coalition of North East Governors. A similar study is being carried out in Whitehorse, YT, to determine the potential of new and retrofit technology to improve efficiency and reduce emissions from stoves, in an area that has one of the most severe wood smoke pollution problems in North America. Results to date indicate that high technology non-catalyst stoves consistently give significantly better performance under controlled conditions in laboratories. Support for this program has also been carried out within ERL. Work is focused on the potential for developing retrofit catalyst technology and operational guidelines to improve the performance of existing stoves.

In particular, performance trials were carried out on two types of add-on catalysts, on three different stove designs, to improve the performance of existing appliances. One design showed promise, providing the stove was run in a specific fashion, but a high pressure drop resulted in significant spillage of combustion products into the house under real-use conditions. ERL is designing a new add-on catalyst which could be applied to a large number of existing stoves to reduce their pollution potential and improve efficiency.

A number of advanced wood stoves have been tested in the laboratory using both Canadian and US EPA fuel loading criteria. There has also been considerable test procedure development and refinement for CSA, related to the preparation of revisions to CSA B365 and CSA B366 on wood safety certification and installation. ERL is also chairing a task group to develop appropriate criteria for the installation of stoves in tight housing.

INDUSTRIAL WOOD COMBUSTION

A pilot scale industrial wood burning system rated at 250 kW was installed at ERL to develop combustion performance guidelines for commercial and industrial wood chip-fired and other processed wood-fired units. Preliminary trials have been conducted and certain "teething bugs" are being resolved.

ERL participated in the determination of the suitability of a Scandanavian municipal solid waste (msw) incinerator for a cogeneration facility burning unhogged wood waste in Northern Ontario. This evaluation included a field trial conducted on an existing msw incinerator of similar combustion design in Denmark. ERL recommended significant design changes to allow it to burn the wood waste and these have been incorporated in the final design.

A testing program was carried out to prove the technical feasibility of drying a wide range of waste materials, including paper mill and agricultural sludges. The fuels produced burned readily on bench scale systems. Technology development to determine the suitability related to larger combustion systems will be carried out.

FUELS CHARACTERIZATION

OBJECTIVE

To evaluate and develop emerging analytical methods and novel instrumentation for characterizing fuel and product quality.

ACHIEVEMENTS:

STANDARDS

Presented a report to the Coal Association of Canada on the activities of the American Society for Testing and Materials (ASTM) relevant to the needs of the coal producer and user.

Coordinated under the auspices of ASTM in cooperation with seven industrial and four public sector laboratories from Canada and the US the adoption of a new industry standard for the determination of arsenic and selenium in coal.

Convinced the International Organization for Standardization (ISO) as a representative of Canada in conjunction with delegations from Sweden and Denmark to include solid process residues within the scope of activities of Technical Committee 27 (TC 27) on coal.

Expanded CANMET's Service Program for the Evaluation of Characterization Standards (CANSPECS) (exchange program for Canadian commercial coals) to include coal ash and solid combustion residues. Sixty laboratories in Canada and abroad supplied standard analysis for three coals. Reports were supplied to industry for quality control purposes and to standards writing organizations to initiate or to prevent changes to industry standards.

DEVELOPMENT

Developed and licensed to UHV Instruments of Burlington a device which eliminates the potential for specimen contamination or oxidation by permitting testing of solids in atmospheres simulating hostile processing environments and subsequent transfer to sterile analytical conditions without air exposure.

Signed an agreement permitting National Vacuum Technologies to technically evaluate and investigate the sales potential for a vacuum transfer vessel with combination instrument case and shipping container which allows the transfer of sensitive samples to and between ultra high vacuum chambers.

Completed preliminary instrumental testing of a rapid modified version of the industry standard Robinson GC/MS procedure for distillate analysis.

Through CGSB, continued to take a lead role in coordinating the development of an NMR method for estimating the cetane number of diesel fuel.

CLIENT SUPPORT

Expanded client services to include automated equipment which permits low pressure distillation of high boiling fractions and particle size analysis.

Performed 15000 analyses on 6000 samples for in-house research projects ($1.3 M), in support of interlaboratory exchange programs ($140 K), and as cost recovery for industrial clients ($60 K).

Participated on a continuing basis in four external interlaboratory round robin programs, the CGSB Cooperative Fuels and Lubricants Monthly Exchange, the ACOSA heavy oil round robin, the AASHTO asphalt round robin and the Standard Laboratory Round Robin program for coal.

ENGINEERING, DESIGN, CONSTRUCTION AND SUPPORT SERVICES

Engineering, design, equipment development and information services were provided to all areas of the division.

The equipment development shop completed requests as needed by ERL personnel for urgent repairs and modifications to experimental and prototype equipment.

The section coordinated 400 requests from ERL for services from the Technical Sercvices Division.

Twenty-two projects were initiated which required discussion and subsequent planning with Public Works Canada including:

- renovations to room 218, building 1
- unit heaters for building 1
- installation of 600 V, 250 amp power for tunnel furnace combustion air heater, building 1
- air conditioning and humidity control for the scanning electron microscope area, building 3
- circulating fluidized bed combustor structual support and control room, building 2
- gas cylinder and chemical storage, building 3
- fumehood scrubbers, building 3
- modification to lunchrooms, building 5

The information services arm performed literary editing of all division reports, provided information services, organized numerous tours of the facilities and was responsible for compiling and editing the division's 1987/88 Annual Report.

APPENDIX A

PROFESSIONAL, TECHNICAL AND SUPPORT STAFF

PROFESSIONAL, TECHNICAL AND SUPPORT STAFF

D.A. Reeve	B.Sc., Ph.D. (Birmingham)	Director
M. Pelletier		Secretary

ADMINISTRATIVE SERVICES

L. Patrick	Admin. Officer
A. Baldock	Clerk
L. Bordua	Clerk
L. Forieri	Rec/Ship (Stores)
D. Fournier	Clerk
J. Gosende	Secretary
M. Grebenc	Clerk
J. Haw	Secretary
J. Hogan	A/Admin.Officer/ Clerk
P. Hughes	Clerk
A. Lamar (Term)	Admin. Officer
W. Lauzon	WPO
M. Lyttle	WPO
G. McCallum	WPO
M. Rivoire	Clerk
K. Schumann (Term)	Clerk
A. Splett	Clerk
B. Vincent	Clerk

ENGINEERING, DESIGN, CONSTRUCTION AND SUPPORT SERVICES

L.P. Mysak	Dipl. Mech. Tech. (Algonquin), B.A.Sc., M.Eng. (Ottawa), P.Eng.	Engineer
D.M. Arsenault		Millwright
J.M. Dowdall		Machinist
J.L. Harcourt		Inf. Officer
R.W. Taylor		Technologist

SYNTHETIC FUELS RESEARCH LABORATORY

J.M. Denis	B.A.Sc. (Ottawa), P.Eng.	Manager

Primary Upgrading

D.J. Patmore	B.Sc. (Bristol), Ph.D. (Alberta)	Res. Sci.
K. Belinko	B.Sc., Ph.D. (Carleton)	Res. Sci.
T.J.W. de Bruijn	B.Sc., M.Sc., Ph.D. (Delft)	Res. Sci.
J. Chase	B.Sc.Chem. (Acadia), B.Sc. Chem.Eng. (McGill), Ph.D. (Univ. of London)	Res. Sci.
W.H. Dawson	B.Sc. (McGill), Ph.D. (Western Ontario)	Res. Sci.
D.D.S. Liu	B.Chem.Eng. (N. Taiwan Univer.), Ph.D. (Dalhousie), P.Eng.	Res. Sci.
P. Sears	M.A., Ph.D. (Cambridge)	Res. Sci.
G. Noel	Dipl. Ind. Chem. Tech. (CGEP, Hull)	Technologist

Process Development

R.B. Logie	B.Sc. (New Brunswick), P.Eng.	Engineer
R.W. Beer		Technologist
A.J.G. Cooke	Dipl. Mech. Tech. (Algonquin)	Technologist
R.W. Devlin	Dipl. Forestry (Sault Ste Marie)	Technologist
R.S. Eagleson		Technologist
V. Feres		Technologist
A.J. Kuiper	Dipl. Biochem. Tech. (Algonquin)	Technologist
P.E. Landry	Dipl. Mech. Tech. (Algonquin)	Technologist
R.N.L. Lycett		Technologist
G.J. McColgan	Dipl. Journalism (Algonquin)	Technologist
C.A.W. McNabb	Dipl. Mech. Tech. (Algonquin)	Technologist
P.J. Mulvihill	Dipl. Ind. Chem. (Algonquin)	Technologist
V.R. Phillips	Dipl. Mech. Tech. (Algonquin)	Technologist

Bitumen/Oil Recovery

A.E. George	B.Sc., M.Sc., Ph.D. (Cairo)	Res. Sci.
K.N. Jha	B.Sc.(Hons.), M.Sc., Ph.D. (Alberta), M.B.A. (Alberta)	Res. Sci.
R.J. Lafleur	B.A. (Ottawa), B.A.Sc. (Waterloo), M.Sc. (Alberta), P. Eng.	Res. Sci.

Coal Processing

J.F. Kelly	B.Eng., Ph.D. (McGill), P.Eng.	Res. Sci.
S.A. Fouda	B.Eng. (Cairo), M.A.Sc., Ph.D. (Waterloo)	Res. Sci.
M. Ikura	B.Eng. (Himeji), M.Eng. (Osaka), Ph.D. (McGill), P.Eng.	Res. Sci.
P. Rahimi	B.Sc. (Iran), M.Sc. (Brock), Ph.D. (Alberta)	Res. Sci.
A.D. Agnew		Technologist
R.F. Campbell		Technologist
D.M. Dick		Technologist
E. Estwick		Technologist
J.E. Whiten		Technologist

Catalytic Processing

J.F. Kriz	Dipl.Eng. (Prague), Ph.D. (Dalhousie), P.Eng.	Res. Sci.
C.W. Fairbridge	B.Sc., M.Sc. (Lakehead), Ph.D. (St. Andrews)	Res. Sci.
J. Monnier	B.A.Sc. (Laval), Ph.D. (McMaster), P.Eng.	Res. Sci.
S.H. Ng	B.Chem.Eng. (Taiwan), Ph.D. (New Brunswick), Eng., Chem.	Res. Sci.
M.V.C. Sekhar	B.Sc. (Madras), M.Sc. (ITT-Madras), Ph.D (Calgary)	Res. Sci.
M.F. Wilson	B.Sc., Ph.D. (St. Andrews)	Res. Sci.
E. Bonvie		Technologist
M.R. Fulton	Dipl. Chem. Tech. (Algonquin)	Technologist
E.C. McColgan		Technologist
M. Stolovitsky	Dipl. Biochem. Tech. (Algonquin)	Technologist

Hydrocarbon Conversion

M. Ternan	B.A.Sc. (British Columbia), Ph.D. (McGill), P.Eng.	Res. Sci.
V.M. Allenger	B.Eng. (McGill), M.A.Sc. (Ottawa), Ph.D. (Ottawa), P.Eng.	Res. Sci.
J.Z. Galuszka	B.Sc., M.Sc., Ph.D. (Cracow)	Res. Sci.
G. Jean	D.E.C., B.Sc., Ph.D. (Western Ontario)	Res. Sci.
P.S. Soutar	Dipl. Mech. Tech. (Algonquin)	Technologist

Hydrocarbon Separation

H. Sawatzky	B.S.A., M.S.A., Ph.D. (Toronto)	Res. Sci.
P. Chantal	B.Sc., M.Sc., Ph.D. (Laval), ing.	Res. Sci.
B. Farnand	B.A.Sc., Ph.D. (Ottawa), P.Eng.	Res. Sci.
S.M. Ahmed	B.Sc., M.Sc. (India)	Chemist

COMBUSTION AND CARBONIZATION RESEARCH LABORATORY

G.K. Lee	B.Sc., M.Sc. (Queen's), P.Eng., C.Eng.	Manager
P. Pint	B.A.Sc., M.A.Sc., Ph.D. (Toronto), P.Eng.	Res. Coord.

Coal Treatment and Coke Processing

T.A. Lloyd	B.Sc. (Carleton)	Phys. Sci.
J.W. St. James	B.Sc. (Waterloo)	Phys. Sci.
R.G. Fouhse	B.Sc. (Saskatchewan), P.Eng.	Engineer
P.A. Couturier		Technologist
R.K. Graham		Technologist
P. Malaiyandi		Technologist
R.R. Bell		Coke Oven Tech.
R.F. Dowdall		Coke Oven Tech.
D.S. Ketchum		Coke Oven Tech.
K. Newhook		Coke Oven Tech.

Carbonization Research

J.T. Price	B.Sc. (Calgary), Ph.D. (Western Ontario)	Res. Sci.
J.F. Gransden	B.Sc. (London), A.R.S.M., Ph.D. (Western Ontario)	Res. Sci.
W.P. Hutny	M.Sc., Ph.D. (Cracow)	Res. Sci.
J.G. Jorgensen	B.Sc. (Carleton)	Phys. Sci.
D.D. Cameron	Dipl. Mech. Eng. (Ryerson)	Technologist
G.H. Dicks	Dipl. Mech. Tech. (Algonquin)	Technologist
K.F. Hampel	Dipl. Ind. Chem. (Algonquin)	Technologist
M.J. Malette		Technologist
N.R. Manery	Dipl. Min. Tech. (Ste Claire)	Technologist
N.J. Ramey	Dipl. Min. Tech. (Haileybury)	Technologist

Energy Conservation Technology

A.C.S. Hayden	B.Eng., M.Eng. (Carleton), P.Eng.	Res. Sci.
S.W. Lee	B.Sc. (Rangoon), Ph.D. (McMaster)	Res. Sci.
F. Preto	B.A.Sc. (Toronto), Ph.D. (Queen's)	Res. Sci.
K. Tait	B.Sc., M.Sc. (London) (Interchange Canada)	Res. Sci.
R.W. Braaten	B.Eng. (Carleton), P.Eng.	Phys. Sci.
N. Laird	B.Sc. (McGill)	Phys. Sci.
M. Wiggin	B.A.Sc. (Waterloo)	Engineer
D.E. Barker		Technologist
D.C. Post	Dipl. Inst. Tech. (Algonquin)	Technologist
H.P. Raghunandan	Dipl. Mech. Tech. (Algonquin)	Technologist
T.G. Sellers		Technologist

Emerging Energy Utilization Systems

F.D. Friedrich	B.Sc. (Saskatchewan), M.Sc. (Queen's), P.Eng.	Res Sci.
E.J. Anthony	B.Sc., B.A. (open university) Ph.D. (Swansea), C.Chem.	Res. Sci.
D.L. Desai	B.E. (Sardar Patel), M.Eng. (Uttawa), P.Eng.	Engineer
I.T. Lau	B.Sc. (Cmengkunk), M.A.Sc. (Ottawa)	Engineer
V.V. Razbin	Dipl. Eng. (Sofia), M.Sc.Eng. (Carleton)	Engineer
W.J. Birtch		Technologist
D.H.J. McLaughlin		Technologist
R.K. Jeffrey		Technologist
F.L. Wigglesworth		Elec. Tech.

Industrial Combustion Processes

H. Whaley	B.Sc., Ph.D. (Sheffield), P.Eng., C.Eng.	Res. Sci.
C.J. Adams	B.Sc., M.Sc. (McGill), Ph.D. (McMaster), P.Eng.	Res. Sci.
G.N. Banks	B.A. (British Columbia)	Res. Sci.
P.M.J. Hughes	B.Sc. (Waterloo), M.Sc. Mech. Eng. (Waterloo)	Res. Sci.
K.V. Thambimuthu	B.Sc. (Birmingham), M.Eng. (McGill), Ph.D. (Cambridge), C.Eng.	Res. Sci.
R.J. Philp	M.App.Sc. (Toronto), P.Eng.	Engineer
J.K.L. Wong	B.Sc. (Calgary)	Phys. Sci.
D.C. MacKenzie	Dipl. Eng. (Cambrian College)	Technologist
R. Nadarajah	B.Sc. (Aston), P.Eng.	Technologist
B.C. Post		Technologist
A. Salamon		Technologist
D.G. Savignac	Dipl. Mech. Tech. (Algonquin)	Technologist
R.J. Lacelle		Elec. Tech.

Gasification

E. Furimsky	Dipl. Eng. (Prague), Ph.D. (Ottawa)	Res. Sci.
A. Palmer	B.Sc. (Montreal)	Res. Sci.
M.W. Channing	Dipl. Forest. Tech. (Sir Sanford Fleming)	Technologist
M. Légère	Dipl. Surv. Tech. (Ryerson)	Technologist
V. O'Connor		Technologist
D. Smith	Dipl. Instr. Tech. (Algonquin)	Technologist

Coal and Coke Constitution

B.N. Nandi	B.Sc., M.Sc. (Calcutta), Dr.Eng. (Karlsruhe)	Res.Sci.
J.A. MacPhee	B.Sc. (St. Francis Xavier), Ph.D. (British Columbia)	Res. Sci.
L.A. Ciavaglia	B.Eng. (Carleton), P.Eng.	Phys. Sci.
B.H. Moffatt		Technologist
S.E. Nixon		Technologist

Project Monitoring and Engineering Design

S.I. Steindl	Dipl. Eng. (Budapest), M.Sc. (Queen's), P.Eng.	Engineer

FUELS CHARACTERIZATION RESEARCH LABORATORY

L.C.G. Janke	B.Sc. (Laurier), B.Ed. (Queen's)	Manager

Surface Spectroscopy and Hydrocarbon Component Characterization Section

J.R. Brown	B.Sc., Ph.D. (Western Ontario)	Res. Sci.
S. Coulombe	D.E.C., B.Sc., Ph.D. (Montreal)	Res. Sci.
J.Z. Skulski	Chem. Eng. (Wroclaw, Poland)	Chemist
M.D. Farrell	B.Sc. (Carleton)	Phys. Sci.
M. Skubnik	B.Eng., M.Eng. (Bratislava) P.Eng.	Phys. Sci.
G.T. Smiley	Dip. Chem. Eng. (Ryerson)	Technologist
L.E. Galbraith	B.A. (Carleton)	Technologist
T.G. Moher	Dipl. Chem. Tech. (Algonquin)	Technologist
R.W. Dureau	Dipl. Chem. Tech. (Algonquin)	Technologist
T. Psutka	B.Sc. (Carleton)	Technologist
N.R. McLean	B.Sc. (Concordia)	Technologist

Fuel Quality Assessment Section

D.M. Clugston	B.Sc., Ph.D. (McMaster)	Chemist
V. Whelan	B.Sc. (Waterloo)	Chemist
R. Prokopuk	B.Sc. (Alberta)	Phys. Sci.
E. Kowalchuk		Technologist
J. Glasa	Cert. Matric. (Bratislava)	Technologist
D.J.A. Dion	Dipl. Chem. Tech. (CGEP, Hull)	Technologist
P.M. MacDonald		Technologist
B. Grossman	Dipl. Chem. Tech. (Algonquin)	Technologist
K.M. Hollington	Dipl. Chem. Tech. (Algonquin)	Technologist
G. Kodybka	Dipl. Chem. Tech. (Algonquin)	Technologist
S. Laplante	Dipl. Chem. Tech. (CGEP, Hull)	Technologist
G.R. Lett	Dipl. Chem. Tech. (Algonquin)	Technologist
D. Rioux		Technologist
M. Skaff		Technologist
D. Whitehead		Technologist
I. Clelland	B.Sc. (Guelph)	Technologist

STAFF CHANGES

Secondments

Deans, D. to Mineral Sciences Laboratories

Fairbridge, C.W. to RPD

Gilmour, S. to Financial Management Branch

Retirements

Taylor, R.W.

Beer, R.W.

Fouhse, R.G.

Resignations

Brazeau, L.

St. Louis, R.A.

Deceased

Faurshou, D. (May 12, 1987)

APPENDIX B

REPORTS, PUBLICATIONS, PRESENTATIONS AND PATENTS

CANMET REPORTS

87-2E	Metallurgical coals in Canada: resources, research and utilization	J.T. Price J.F. Gransden
87-4E	A data package for the validation of a computer model of the CCRL tunnel furnace facility.	P.M.J. Hughes

TEXT BOOK PUBLICATION

The combustion of coal-liquid mixtures, in: Principles of Combustion Engineering for Boilers, ed. C.J. Lawn, Adademic Press, London, U.K.	K.V. Thambimuthu H. Whaley

DIVISION REPORTS

JOURNAL SUBMISSIONS (J)

ERL 87-42(J)	Hydrogenation and extraction of aromatics from oil sands distillates and effects on cetane improvement	M.F. Wilson I.P. Fisher J.F. Kriz
ERL 87-43(J)	Utilization of the residual pitch from CANMET hydrocracking	K. Belinko B. Pruden
ERL 87-53(J)	Deoxygenation of sorbitol over ZSM-5 and Fe/ZSM-5 catalysts	P.D. Chantal G. Jean S. Coulombe A. Mahay S. Kaliaguine
ERL 87-54(J)	Mechanism of regeneration of iron oxide containing sorbents used for hot gas clean-up	A. Palmer P. Heeney E. Furimsky
ERL 87-58(J)	Comment CANMET s'est debarrassé du coke	J.M. Denis K. Belinko M. Perrault
ERL 87-59(J)	Capture and rebound of dust in granular bed gas filters	J.R. Coury K.V. Thambimuthu R. Clift
ERL 87-62(J)	Pore structure engineered catalysts for hydrocracking heavy feeds	M.V.C. Sekhar
ERL 87-63(J)	Evaluating coal for blast furnace injection - importance of coal tar yields	W.P. Hutny J.T. Price
ERL 87-75(J)	Effect of coal structure on ignition temperature	E. Furimsky
ERL 87-76(J)	Zinc chloride catalyzed flash hydro-pyrolysis of +525°C pitch from Cold Lake bitumen	R.N. Pandey E. Ingard M. Ternan
ERL 87-78(J)	Solid superacid catalysts and the reactions they catalyze	R.N. Pandey V.M. Allenger
ERL 87-82(J)	On Fe catalyzed gasification of char in CO_2	E. Furimsky P. Sears
ERL 87-86(J)	Analysis and empirical (regression) model of blast furnace coal injection	W.P. Hutny J.T. Price

ERL 87-93(J)	Stability of premixed natural gas and coke oven gas flames in a cylindrical furnace	W.P. Hutny J.C. Wang G.K. Lee
ERL 88-16(J)	Characteristics of CANMET coprocessing distillates obtained at various coal concentrations	P.M. Rahimi S.A. Fouda J.F. Kelly
ERL 88-22(J)	On H_2S removal from hot gas in the presence of Cu containing sorbents	T. Kyotani H. Kawashima A. Tomita A. Palmer E. Furimsky
ERL 88-24(J)	Effect of O_2 concentration on temperature runaway during regeneration of hydrotreating catalyst	E. Furimsky
ERL 88-25(J)	Oil removed from oilfield produced water by cross flow ultrafiltration	B.A. Farnand
ERL 88-27(J)	Modification of Grayson-Streed method for predicting vapour liquid equilibrium under hydrocracking conditions	I.S. Sambi D.J. Patmore

ORAL PRESENTATIONS (OP)

ERL 87-39(OP)	Supported metal cluster precursors for active hydrotreating catalysts (Abstract only)	P.M. Boorman K.S. Jassim R.A. Kydd C. Fairbridge
ERL 87-40(OP)	Methane polymerization using a hollow cathode	P. Meubus G. Jean
ERL 87-44(OP)	Development of a general model for fluidized bed coal combustion	F. Preto H.A. Becker
ERL 87-47(OP)	Method for determining coal fly ash resistivity for comparison with pilot scale data	H. Whaley J.K. Wong G.N. Banks K.V. Thambimuthu D.G. Savignac
ERL 87-49(OP)	Verification of heat of combustion estimation methods for Canadian petroleum fuels	R.J. Lafleur
ERL 87-50(OP)	Report of the IEA Coal Liquid Mixtures Technical Committee	H. Whaley
ERL 87-61(OP)	Preferential adsorption and selective permeation in reverse osmosis (Abstract only)	B. Farnand

ERL 87-73(OP)	Opportunities for coal utilization by coprocessing in Canada	M. Ikura J.M. Denis
ERL 87-79(OP)	CANMET hydrocracking process - an emerging new technology for upgrading bitumen and heavy oils (Abstract only)	J.M. Denis
ERL 87-81(OP)	Beneficiation of lignites by oil agglomeration using bitumens (Abstract only)	M. Ikura J.F. Kelly C.E. Capes
ERL 87-83(OP)	Gasification of chars formed on the surface of catalysts used for cracking oil sand +525°C pitch (Abstract only)	M. Ternan
ERL 87-98(OP)	Hydrocraquage à basse pression d'un résidu sous vide du bitûme de Cold Lake (Abstract only)	M. Ternan
ERL 87-99(OP)	Influence of coal properties on carbon burnout during combustion (Abstract only)	B.N. Nandi S. Ng J.A. MacPhee
ERL 88-14(OP)	Nitrogen poisoning of catalysts during cracking of nonconventional oils (Abstract only)	S. Ng
ERL 88-15(OP)	Simultaneous polymerization and oligomerization of acetylene on fluoridated alumina catalysts (Abstract only)	V.M. Allenger D.D. McLean M. Ternan
ERL 88-17(OP)	Practical aspects of CARS in combustion research	P.M.J. Hughes
ERL 88-29(OP)	Application of the pseudo-adiabatic catalytic reactor for conversion of synthesis gas into gasoline (Abstract only)	F. Simard A. Mahay A. Ravella H. de Lasa G. Jean
ERL 88-31(OP)	Wax: a key component for correlating composition with rheological properties of asphalt cements (Abstract only)	M.A. Poirier H. Sawatzky
ERL 88-33(OP)	New aspects of coal combustion during blast furnace injection (Extended abstract only)	W.P. Hutny J.T. Price G.K. Lee

ORAL PRESENTATIONS AND JOURNAL SUBMISSIONS (OPJ)

ERL 87-16(OPJ)	Preferential adsorption and selective permeation of alcohol/hydrocarbon mixtures in reverse osmosis	B.A. Farnand H. Sawatzky

ERL 87-19(OPJ)	Treatment of synthetic crudes with metal chlorides and carbonyls	K.R. Dymock H. Sawatzky
ERL 87-28(OPJ)	Molybdenum catalysts supported on hydrous "titanates" for low severity coprocessing of heavy oil and coal	J. Monnier C.W. Fairbridge J.R. Brown J. Kriz
ERL 87-29(OPJ)	Effect of coal concentration on product distribution in CANMET coprocessing	P.M. Rahimi S.A. Fouda J.F. Kelly
ERL 87-30(OPJ)	Inducing mesophase in lignite (Extended abstract)	H. Sastre E. Chornet B.N. Nandi
ERL 87-31(OPJ)	Control of acid rain emissions from Canada's first fluidized bed heating plant	G.K. Lee V.V. Razbin F.D. Friedrich
ERL 87-33(OPJ)	Determining the role of CnHx surface species in hydrocarbon synthesis (Extended abstract)	J. Galuszka Y. Amenomiya
ERL 87-34(OPJ)	Experimental and theoretical study on the deposition of coal-water fuel ash on simulated boiler convective heat transfer surfaces	Z.Q. Zhou K.V. Thambimuthu H. Whaley
ERL 87-36(OPJ)	Oilfield produced water treatment by ultrafiltration	B.A. Farnand T.A. Krug
ERL 87-38(OPJ)	Coprocessing of high volatile bituminous coals	S.A. Fouda J.F. Kelly
ERL 87-41(OPJ)	Improving coke quality using Canadian coals	J.T. Price J.F. Gransden
ERL 87-46(OPJ)	Cretaceous and carboniferous coking coals - a comparison of their properties	J.A. MacPhee J.T. Price J.F. Gransden
ERL 87-51(OPJ)	A temperature-programmed desorption study of the residues from acetylene polymerization on alumina catalysts	V.M. Allenger D.D. McLean M. Ternan
ERL 87-56(OPJ)	Behaviour of bituminous coals under coprocessing conditions	S.A. Fouda J.F. Kelly
ERL 87-64(OPJ)	Flash hydropyrolysis of bituminous caking coal	M. Ikura

ERL 87-67(OPJ)	Combustion performance of Unakawanda lignite in a pilot-scale fluidized bed combustor	E.J. Anthony D.L. Desai F.D. Friedrich M. Beal
ERL 87-77(OPJ)	Reverse osmosis fractionation of organic and inorganic solutes in non-aqueous solutions (Abstract only)	B.A. Farnand
ERL 87-84(OPJ)	FTIR investigation of surface species during C_2H_2 interaction with alumina-supported nickel catalyst	J. Galuszka Y. Amenomiya
ERL 87-85(OPJ)	Statistical experimental design in the hydroprocessing of coal-derived middle distillate (Abstract only)	C. Fairbridge V. Allenger M. Skaff
ERL 87-88(OPJ)	Oxidative regeneration of nickel-molybdate and cobalt-molybdate hydrotreating catalysts	Y. Yoshimura E. Furimsky T. Sato H. Shimada N. Matsubayashi A. Nishijima
ERL 87-89(OPJ)	The new half tonne per day coprocessing pilot plant at CANMET's Energy Research Laboratories (Abstract only)	J.D. Chase
ERL 87-90(OPJ)	Characterization of heteroatomic compounds in various synthetic crude naphthas	T. Yoshida P.D. Chantal H. Sawatzky
ERL 87-94(OPJ)	Determination of fuel aromatic content and its effect on residential oil combustion	S.W. Lee A.C.S. Hayden
ERL 87-95(OPJ)	Exit discontinuity in slurry bubble columns	T.J.W. de Bruijn I.G. Reilly D. MacIntyre D.S. Scott
ERL 87-96(OPJ)	Applications of fractal geometry for characterizing hydrotreating catalysts	C. Fairbridge
ERL 87-97(OPJ)	Hydrocracking of Athabasca bitumen using Co/Mo catalysts supported on wide pore carbon extrudate (Abstract only)	M. Altajam M. Ternan
ERL 88-01(OPJ)	Pulsing flow through small tubes and orifices: simulation of pressure drop in hydrocracking pilot plant	D.D.S. Liu S.S. Hall D.J. Patmore
ERL 88-03(OPJ)	Effect of coal concentration on coprocessing performance	S.A. Fouda J.F. Kelly P.M. Rahimi

ERL 88-04(OPJ)	Beneficiation of lignite by oil agglomeration as an integral part of coprocessing	M. Ikura J.F. Kelly C.E. Capes
ERL 88-05(OPJ)	Heavy oil upgrading using halide catalysts in a bubbling microautoclave	A. Chakma E. Chornet R.P. Overend W.H. Dawson
ERL 88-06(OPJ)	Proposal for a new standard method for determining total aromatics in liquid petroleum fuels by super-critical fluid chromatography	S.W. Lee
ERL 88-08(OPJ)	Application of gamma-ray densitometry in developing primary upgrading processes at CANMET (Extended abstract)	D.D.S. Liu D.J. Patmore
ERL 88-09(OPJ)	Modelling pulverized coal-water slurry combustion	Z.Q. Zhou K.V. Thambimuthu
ERL 88-10(OPJ)	Coal-water fuel conversion and combustion testing in an industrial iron ore pelletizing furnace	K.V. Thambimuthu D.A. Reeve
ERL 88-13(OPJ)	Fireflood recovery process effects on heavy oil properties	C. Reichert B. Fuhr H. Sawatzky R. Lafleur B. Verkoczy K. Jha
ERL 88-18(OPJ)	Effect of recovery processes on the characteristics of produced heavy oil (Abstract only)	K.N. Jha R. Lafleur H. Sawatzky B. Fuhr C. Reichert D. Soveran B. Verkoczy
ERL 88-19(OPJ)	Heavy oil upgrading in a jet reactor (Abstract only)	A. Chakma E. Chornet R.P. Overend W.H. Dawson
ERL 88-21(OPJ)	Effect of the properties of Western Canadian coals on their coking behaviour	J.T. Price J.F. Gransden M.A. Khan
ERL 88-23(OPJ)	Upgrading of Cold Lake heavy oil in the CANMET hydrocracking demonstration plant	B.B. Pruden J.M. Denis G. Muir

ERL 88-26(OPJ)	Application of liquid clathrates for separation of aromatic hydrocarbons from synthetic fuels (Abstract only)	M.F. Wilson M.J. Zaworotko I.P. Fisher
ERL 88-28(OPJ)	Preparation of large pore Ni/SiO_2 catalysts for synfuels hydroprocessing using deposition-precipitation methods	M.F. Wilson O. Antinhuoma J.R. Brown
ERL 88-32(OPJ)	Coking pressure and coke quality at different locations in an industrial oven	J.F. Gransden J.T. Price M.A. Khan

TECHNICAL REPORTS (TR)

ERL 87-32(TR)	Repeatability and reproducibility for coal proximate analyses	M. Farrell
ERL 87-37(TR)	Annual report to the IEA CLM Executive Committee 1985-12-10 to 1986-12-09	H. Whaley
ERL 87-45(TR)	Surface chemistry and reduction behaviour of gamma-alumina supported molybdenum oxide	J.R. Brown
ERL 87-48(TR)	Energy Research Laboratories Annual Report 1986/87	J.L. Harcourt
ERL 87-55(TR)	Pressure drop across an orifice in pulsating gas flows	S.S. Hall D.D.S. Liu D.J. Patmore
ERL 87-60(TR)	Report on workshop on fluidized bed combustion in Canada	E.J. Anthony J.R. Grace
ERL 87-70(TR)	Combustion research at CANMET	E.J. Anthony F.D. Friedrich
ERL 87-71(TR)	Fluidized bed combustion of Devco Prince rejects	E.J. Anthony F.D. Friedrich
ERL 87-74(TR)	Investigation of new column packings for molecular weight determination of heavy fractions by size exclusion chromatography	S. Coulombe S. Desjardins
ERL 87-80(TR)	Expansion/contraction of Western Canadian coal in sole-heated oven and its relation to other properties	J.F. Gransden J.T. Price
ERL 87-87(TR)	Bubbling fluidized bed combustion of Syncrude coke	E.J. Anthony H.A. Becker R.K. Code R.W. McLeave J.R. Stephenson

ERL 87-91(TR)	Test protocol for the CFB Gagetown low NO_x/SO_x	G.K. Lee R.J. Philp
ERL 87-92(TR)	Tube wastage in FBC boilers at Summerside - causes and resolution	F.D. Friedrich
ERL 88-02(TR)	Preliminary investigation of the micro-filtration of oil sands tailings pond sludge	B. Farnand H. Sawatzky
ERL 88-07(TR)	Auger electron spectroscopy techniques for analyzing insulators	M. Farrell
ERL 88-12(TR)	Preparation and surface characterization of bimetallic Cu-Fe thin film catalysts	J.R. Brown L.E. Galbraith R.E. Minto
ERL 88-20(TR)	Bibliography of CANMET publications on coprocessing	Coal Processing Section
ERL 88-30(TR)	Microfiltration for the dewatering of deoiled tailings pond sludge	B. Farnand H. Sawatzky

INVESTIGATION REPORTS (IR)

ERL 87-50(IR)	Comparative combustion properties of raw and washed Donkin coals in the CCRL pilot-scale boiler	G.N. Banks J.K.L. Wong H. Whaley

RESEARCH REPORTS (R)

ERL 87-65(R)	Combustion characteristics of Canadian coals - Volume 1	K. Tait G.N. Banks H. Whaley G.K. Lee
ERL 87-66(R)	Direct use of coal in blast furnace technology	W.P. Hutny J.T. Price

LITERATURE SURVEYS (LS)

ERL 87-72(LS)	Adsorption of probe molecules on Mo/Al_2O_3 catalysts	C. Fairbridge M. Konkin I.G. Dalla Lana

INTERNAL REPORTS (INT)

ERL 87-03(INT)	Instrumentation for 2 bbl/day co-processing pilot plant (PP3): Instrument loop drawings and panel layout, connection diagrams: Contract 03SQ-23440-S-9182	J.D. Chase C.A. McNabb

ERL 87-04(INT)	Preparation of solid adsorbents for hot gas clean-up - Part 3 - Dofasco Inc. materials	A. Palmer M. Légère E. Furimsky
ERL 87-05(INT)	Stability of natural gas and coke oven gas flames in a cylindrical furnace	W.P. Hutny J.C. Wong G.K. Lee
ERL 87-06(INT)	Detection of oxidation in subbituminous coals using microhardness techniques	L. Ciavaglia
ERL 87-07(INT)	Engineering documentation for co-processing pilot plant	J.D. Chase
ERL 88-01(INT)	Comparison of pitch conversion measurements using Podbeilniak and D116U distillations	D.J. Patmore
ERL 88-02(INT)	Proposed method for estimation of net and gross heat of combustion of petroleum fuels	R.J. Lafleur
ERL 88-03(INT)	Evaluation of proposed standard test method ASTM D-32.03 for determination of base metals in fresh catalysts	T.G. Moher
ERL 88-04(INT)	Adsorption of multi-cpomponent nitrogenous and oxygenated compounds using various zeolites and inorganic sorbents	S.M. Ahmed P.D. Chantal
ERL 88-05(INT)	Additive comparison runs, 87-CG-16 to 64: Summary of process operation and product yields	D.J. Patmore T.J.W. de Bruijn D.D.S. Liu P.L. Sears
ERL 88-06(INT)	Combustion and atomization tests on two Cape Breton Development Corporation coal-water fuels made with different dispersants - interim report	K. Thambimuthu J. Wong
ERL 88-07(INT)	Hot gas clean-up at CANMET - update	E. Furimsky
ERL 88-08(INT)	Operator's guide to LECO casting, cutting, grinding and polishing	M. Farrell
ERL 88-09(INT)	Petroleum asphaltenes - abstracts from recent literature.	S.M. Ahmed

CONFIDENTIAL REPORTS = 23

PAPERS PUBLISHED IN OUTSIDE JOURNALS

Allenger, V.M., Fairbridge, C., McLean, D.D. and Ternan, M. "Reaction of acetylene over fluoridated alumina catalysts", J Catal 105:71-80, 1987.

Fairbridge, C., Palmer, A.D., Ng, S.H. and Furimsky, E. "Surface structure and oxidation reactivity of oil sand coke particles", Fuel 66:5:688-691, 1987.

Fisher, I.P. and Wilson, M.F. "Kinetics and thermodynamics of hydrotreating synthetic middle distillates", Am Chem Soc, Div Petrol Chem Preprints 32:2:310, 1987.

Fuhr, B.J., Holloway, L.R., Reichert, C., Lee, S.W. and Hayden, A.C.S. "Determination of aromatics in heating oils and diesel fuels by supercritical fluid chromatography", Am Chem Soc, Div Fuel Chem Preprints 32:4:30, 1987.

Furimsky, E. and Yoshimura, Y. "Mechanism of regeneration of molybdate catalysts", Ind Eng Chem Res 26:657, 1987.

Furimsky, E., Duguay, D. and Houle, J. "Chemisorption of oxygen by coke deposited on catalyst surface", Fuel 67:1, 1988.

Furimsky, E., Houle, J. and Yoshimura, Y. "Use of Boudart reaction for regeneration of hydrotreating catalysts", Applied Catal 33:97, 1987.

Lee, S.W., Fuhr, B.J. and Glavincevski, G. "Evaluation of a new chromatographic method for aromatics in diesel fuels", Society for Automotive Engineers, Technical Paper Series 872142, 1987.

Lynch, B.M., Lancaster, L.I. and MacPhee, J.A. "Carbonyl groups from chemically and thermally promoted decomposition of peroxides on coal surfaces - detection of specific types using photoacoustic infrared Fourier transform spectroscopy", Fuel 66:979-983, 1987.

Mahay, A., Simard, F., Lemay, G., Adnot, A., Kaliaguine, S. and Monnier, J. "Deoxygenation of methanol with carbon monoxide over ZSM-5-supported Fe, Ru, Pd and Rh catalysts", Applied Catal 33:55-71, 1987.

Monnier, J., Dénès, G., Potter, J. and Kriz, J.F. "Catalysts supported on hydrous 'titanates' for hydroprocessing mixtures of heavy oil and coal", Energy Fuels 1:4:332-338, 1987.

Nandi, B.N., MacPhee, J.A., Ciavaglia, L.A., Chornet, E. and Arsenault, R. "Enhancement of plastic properties of inert-rich oxidized cretaceous coals via the water-gas shift reaction", Fuel 66:473-478, 1987.

Ng, S.H., Curts, L.E. and Dymock, K.R. "Catalytic cracking of hydrotreated conventional and synthetic feedstocks", Am Chem Soc, Div Petro Chem Preprints 32:4:858, 1987.

ERL 87-04(INT)	Preparation of solid adsorbents for hot gas clean-up - Part 3 - Dofasco Inc. materials	A. Palmer M. Légère E. Furimsky
ERL 87-05(INT)	Stability of natural gas and coke oven gas flames in a cylindrical furnace	W.P. Hutny J.C. Wong G.K. Lee
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ERL 88-06(INT)	Combustion and atomization tests on two Cape Breton Development Corporation coal-water fuels made with different dispersants - interim report	K. Thambimuthu J. Wong
ERL 88-07(INT)	Hot gas clean-up at CANMET - update	E. Furimsky
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Allenger, V.M., Fairbridge, C., McLean, D.D. and Ternan, M. "Reaction of acetylene over fluoridated alumina catalysts", J Catal 105:71-80, 1987.

Fairbridge, C., Palmer, A.D., Ng, S.H. and Furimsky, E. "Surface structure and oxidation reactivity of oil sand coke particles", Fuel 66:5:688-691, 1987.

Fisher, I.P. and Wilson, M.F. "Kinetics and thermodynamics of hydrotreating synthetic middle distillates", Am Chem Soc, Div Petrol Chem Preprints 32:2:310, 1987.

Fuhr, B.J., Holloway, L.R., Reichert, C., Lee, S.W. and Hayden, A.C.S. "Determination of aromatics in heating oils and diesel fuels by supercritical fluid chromatography", Am Chem Soc, Div Fuel Chem Preprints 32:4:30, 1987.

Furimsky, E. and Yoshimura, Y. "Mechanism of regeneration of molybdate catalysts", Ind Eng Chem Res 26:657, 1987.

Furimsky, E., Duguay, D. and Houle, J. "Chemisorption of oxygen by coke deposited on catalyst surface", Fuel 67:1, 1988.

Furimsky, E., Houle, J. and Yoshimura, Y. "Use of Boudart reaction for regeneration of hydrotreating catalysts", Applied Catal 33:97, 1987.

Lee, S.W., Fuhr, B.J. and Glavincevski, G. "Evaluation of a new chromatographic method for aromatics in diesel fuels", Society for Automotive Engineers, Technical Paper Series 872142, 1987.

Lynch, B.M., Lancaster, L.I. and MacPhee, J.A. "Carbonyl groups from chemically and thermally promoted decomposition of peroxides on coal surfaces - detection of specific types using photoacoustic infrared Fourier transform spectroscopy", Fuel 66:979-983, 1987.

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Farnand, B.A. and Sawatzky, H. "Membrane separation process for the removal of methanol from hydrocarbon mixtures including oxygenates", CANMET Case 49.

Farnand, B.A. and Chase, J.D. "A combined methanol-acid membrane separation process", CANMET Case 60.

Farnand, B.A. and Fairbridge, C. "Membrane reactor", Patent Agent's File 26154.

Kaliaguine, S. and Monnier, J. "Catalyst for production of hydrocarbons from synthesis gas or oxygenated organic compounds", Canadian Serial No. 540, 274, June 22, 1987.

Mikhlin, A.J., Ikura, M., Kelly, J.F. and Capes, C.E. "Coal agglomeration beneficiation with heavy hydrocarbon oils and utilization thereof in coal/heavy oil coprocessing", Canadian Patent Application 542049.

APPENDIX C

REPRESENTATION ON TECHNICAL COMMITTEES

INTERNATIONAL

AIR POLLUTION CONTROL ASSOCIATION
- APCA TS-2.3, Residential Fuel Combustion (chairman)..... A.C.S. Hayden
- APCA TS-2.2, Industrial Fuel Combustion (secretary)..... A.C.S. Hayden
- APCA International Office (member)..... S.W. Lee
- APCA Ottawa Chapter (secretary)..... S.W. Lee
- APCA Quebec Section Executive (past chairman)..... R.J. Lafleur

BRITISH FLAME RESEARCH COMMITTEE (member)..... G.K. Lee

CANADA/JAPAN COAL LIQUEFACTION PROGRAM (Canadian coordinator) D.A. Reeve
- Working Group (secretary)..... M. Ikura

FUEL (London) (Regional editor)
- International Editorial Board (Canadian editor)..... A.E. George

FUEL SCIENCE AND TECHNOLOGY INTERNATIONAL (USA)
- International Editorial Board ..... A.E. George

INTERNATIONAL COMMITTEE ON COAL PETROGRAPHY
- Petrography (working member)..... B.N. Nandi
- Petrography of Organic Sediments (member)..... B.N. Nandi
- Subcommittee on Industrial Application of Coal Petrography (member)..... B.N. Nandi

INTERNATIONAL COMMITTEE ON COAL RESEARCH (member)..... D.A. Reeve

INTERNATIONAL COMMITTEE ON FUELS AND LUBRICANTS (member)..... S. Coulombe

INTERNATIONAL CONGRESS ON CATALYSIS (1988)
- Advertising and Publications Committee (chairman)..... M. Ternan
  (member)..... J. Monnier
- Technical Program Committee (members)..... J.F. Kriz
  ..... J.R. Brown

INTERNATIONAL DISTRICT HEATING AND COOLING ASSOCIATION
- International Relations Committee (chairman)..... M. Wiggin
- Research and Development Committee (vice chairman)..... M. Wiggin

INTERNATIONAL ENERGY AGENCY
- Fossil Fuels Working Party (member)..... D.A. Reeve
- Coal Research Executive Committee (member)..... D.A. Reeve
- International Conference on Coal Science (Canadian representative)..... J.T. Price
- Coal-Liquid Mixture Implementing Agreement..... H. Whaley
- Atmospheric Fluidized Bed Combustion Agreement..... F.D. Friedrich
  ..... E.J. Anthony
- Low NO_x Coal Combustion of Pulverized Coal Agreement.... G.K. Lee
- Coal Combustion Sciences Implementing Agreement..... G.K. Lee
  ..... H. Whaley
  ..... P.M.J. Hughes

District Heating Implementing Agreement..... M. Wiggin
Advanced Heat Pump Implementing Agreement..... M. Wiggin

INTERNATIONAL FLAME RESEARCH FOUNDATION
Aerodynamics Panel (member)..... H. Whaley
Flame Chemistry Panel (member)..... E.J. Anthony
Joint Committee (member)..... G.K. Lee
Pulverized Coal Panel (member)..... H. Whaley
Oil and Gas Panel (member)..... A.C.S. Hayden

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)
ISO/TC-27 Solid Mineral Fuels, Canadian Advisory
Committee (chairman)..... L. Janke
(member at large)..... R. Prokopuk
ISO/TC-27/SC-2 Brown Coals and Lignites (secretary)..... L. Janke
(member at large)..... R. Prokopuk
ISO/TC-27/SC-2/WG-15 Coal Abrasion (member)..... R. Prokopuk
ISO/TC-27/SC-3 Coke (member)..... J.F. Gransden
ISO/TC-27/WG-12 Plasticity (member)..... T.A. Lloyd
ISO/TC-28 Petroleum Products, Canadian Advisory
Committee (member at large)..... R. Prokopuk
ISO/Remco Committee on Reference Materials, Canadian
Advisory Committee (member at large)..... R. Prokopuk
ISO/TC-102/SC-3 Physical Testing of Iron Ores (chairman). J.T. Price
ISO/TC-109 Domestic Oil Burners (member)..... A.C.S. Hayden
ISO/TC-146/SC-1 Air Quality - Stationary Source Emissions
(member)..... H. Whaley

INTERNATIONAL SOCIETY FOR CHEMICAL REACTION ENGINEERING
Canadian International Symposium on Chemical Reactor
Engineering (1990) Organizing Committee (member)..... J.F. Kelly

SWEDEN/CANADA MEMORANDUM OF UNDERSTANDING ON ENERGY
CONSERVATION TECHNOLOGY
District Heating Coordination..... M. Wiggin

US/CANADA INTERAGENCY WOOD COMBUSTION
Research Group (member)..... A.C.S. Hayden

US/CANADA MEMORANDUM OF UNDERSTANDING FOR COOPERATION ON RESEARCH
AND DEVELOPMENT IN TAR SANDS (OIL SANDS) AND HEAVY OIL
Executive Committee (Canadian co-chairman)..... D.A. Reeve
(Canadian secretary)..... A.E. George
(Canadian member)..... H. Sawatzky
Technical Working Party (members)..... H. Sawatzky
..... R. Lafleur
..... A.E. George
..... K.N. Jha

US DEPARTMENT OF ENERGY/EMR MEMORANDUM OF UNDERSTANDING
ON ENERGY R&D
Management Committee (member)..... D.A. Reeve

WOOD HEATING ALLIANCE
Engineering Committee (member)..... A.C.S. Hayden
Emissions Testing (member)..... R.W. Braaten

CANADA/WEST GERMANY COOPERATIVE AGREEMENT ON SLURRY
PIPELINING AND COMBUSTION..... G.K. Lee
..... H. Whaley

UNITED STATES OF AMERICA

AMERICAN CHEMICAL SOCIETY
Division of Fuel Chemistry (member)..... S.W. Lee

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Environmental Control Division General Committee
(member)..... H. Whaley
Combustion and Fuels Technology Research Committee
(members)..... G.K. Lee
..... H. Whaley
Research Committee on Corrosion and Deposits from
Combustion Gases (member)..... G.K. Lee
Honors and Awards Committee, Papers Review,
Fuels and Combustion Technologies (member)..... H. Whaley
Environmental Control Division (vice chairman
and treasurer)..... H. Whaley
American Power Conference Organization Committee
(member)..... H. Whaley
Percy Nicholls Award Committee (member)..... G.K. Lee

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
Committee on Standards (member)..... L. Janke
Committee D-2 Petroleum Products and Lubricants
(members)..... V. Whelan
..... R.J. Lafleur
(member at large)..... R. Prokopuk
Committee D-4 Road and Paving Materials (member at large) R. Prokopuk
Committee D-5 Membership Secretary..... L. Janke
Committee D-5 Executive (member)..... L. Janke
Committee D-5 (secretary)..... L. Janke
Committee D-5 Coal and Coke (members)..... V. Whelan
..... T. Psutka
(member at large)..... R. Prokopuk
Committee D-8 Roofing, Waterproofing and Bituminous
Materials (member at large)..... R. Prokopuk
Committee D-19 Water (member)..... T. Psutka
Committee D-32 Catalysis (members)..... C. Fairbridge
..... S.H. Ng
Committee D-34 Waste Disposal (member)..... E.J. Anthony
Committee D-38 Utilization of Waste Materials (member)... E.J. Anthony
Committee D-22 Environmental Monitoring and Assessment
(member)..... R. Prokopuk
Committee E-2 Atomic Spectroscopy (members)..... S. Coulombe
..... T. Moher
Committee E-14 Mass Spectroscopy (member)..... G. Smiley

Committee E-19 Chromatography (members)..... T. Psutka
..... S. Coulombe
..... G. Smiley
Committee E-42 Surface Spectroscopy (members)..... J.R. Brown
..... M. Farrell
Subcommittee E-42.02 Terminology (member)..... J.R. Brown
Subcommittee E-42.03 Auger Electron Spectroscopy (member) J.R. Brown
Subcommittee E-42.04 X-ray Photoelectron Spectroscopy (member).....J.R. Brown
Subcommittee E-42.09 Standard Reference Materials (member)..... J.R. Brown
Committee TO2 Zeolites (member)..... J. Galuszka
Subcommittee D-5-07 Physical Properties of Coal (member)..... T.A. Lloyd
Subcommittee D-5-22 Physical Testing of Coke (member).... T.A. Lloyd
Subcommittee D-5-28 Petrographic Analysis of Coal (members)..... B.N. Nandi
..... J.C. Jorgensen
Thermodynamic Performance of Solid Fuel Appliances..... R.W. Braaten

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS
(member at large)..... R. Prokopuk

NATIONAL ENGINEERING FOUNDATION
Fuels for Tomorrow Conference Organizing Committee (member)..... G.K. Lee
Fouling and Slagging from Fuel Impurities Conference Organizing Committee (member)..... G.K. Lee

UNITED STATES OF AMERICA FOREST PRODUCTS RESEARCH
Society Editorial Review Board (member)..... D.P.C. Fung

UNITED STATES DEPARTMENT OF ENERGY
Venting of Combustion Appliances (member)..... A.C.S. Hayden

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..... M. Wilson
Committee on Fuels and Lubricants (member)..... S. Coulombe
Committee 3-GP, Petroleum Test Methods Subcommittee (member)..... M.F. Wilson
Committee on Middle Distillate Fuels (member)..... A.C.S. Hayden
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Committee on Gasoline and Alternative Automotive Fuels (member)..... A.C.S. Hayden
Committee on Petroleum Products (member)..... R.J. Lafleur
Committee on Test Methods (member)..... R.J. Lafleur

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Technical Committee (chairman)..... F.D. Friedrich
(member)..... V.V. Razbin
Canada/Saskatchewan Heavy Oil/Fossil Fuels Agreement
Management Committee (member)..... D.A. Reeve
Technical Advisory Committee (member)..... A.E. George
CANMET Communications and Marketing Committee
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(alternate)..... J. Harcourt
CANMET Hydrocracking
Liaison Committee (chairman)..... J.M. Denis
Patents and Publications Committee (member)..... J.M. Denis
Patents Coordination Committee (member)..... D.J. Patmore
EMR/Petro-Canada Progress Review Committee (secretary) K. Belinko
EMR/Petro-Canada Joint Technical Committee (member)... K. Belinko
CANMET Coprocessing Policy Committee (member)..... J.F. Kelly
Intra-departmental Working Group on Environmental Issues (member)..... P. Pint
Working Group Canada/Japan Coal Liquefaction Program (secretary)..... M. Ikura
ERL Business Coordination Group (chairman)..... K. Belinko
(members)..... L. Janke
..... S. Fouda
..... P. Pint
..... J. Harcourt

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Committee on Retrofit Devices and Additives (member).... A.C.S. Hayden
Committee on Fuels and Lubricants (members)..... M.F. Wilson
..... S.W. Lee
Task Force on Indoor Air Quality (chairman)..... A.C.S. Hayden
Technical Advisory Committee for Ground Source Heat Pumps (member)..... M. Wiggin
Committee on Energy Storage (member)..... M. Wiggin
Committee on Energy Systems R&D (chairman)..... M. Wiggin
Committee on Liquid Fuels in Transportation (member).... A.C.S. Hayden
Committee on Biomass R&D (member)..... A.C.S. Hayden
Lead in Gasoline (member)..... A.C.S. Hayden
Fuel Committee (member)..... F.D. Friedrich
Management Committee for CANMET Hydrocracking (chairman)..... J.M. Denis

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- Committee on Emissions from Residential Combustion Appliances (chairman)..... A.C.S. Hayden

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- University/Industry Research Chair Program
  - Technical Ad Hoc Committee (chairman and member)..... J.R. Brown

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- Underground Test Facility
  - Management Committee (member)..... A.E. George
  - Technical Committee (member)..... A.E. George
- Taciuk Process for Treating Sludges
  - Management Committee (member)..... A.E. George
  - Technical Committee (member)..... R. Lafleur
- Horizontal Laterals for Recovery of Athabasca Bitumen
  - Technical Committee (member)..... A.E. George
- Upgrader Residue Utilization Study
  - Management Committee (member)..... F.D. Friedrich
  - (alternate)..... J.M. Denis

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- Project on Circulating AFBC Waste Characteristics (technical adviser)..... E.J. Anthony
- Project on Flame Scanners for Coal Firing Monitoring (technical adviser)..... P.M.J. Hughes
- Project on Furnace Modelling ..... G.K. Lee
- Project on TransAlta Slagging Combuster ..... G.K. Lee

CANADIAN CARBONIZATION RESEARCH ASSOCIATION
- Board of Directors (member)..... D.A. Reeve
- (secretary)..... J.T. Price
- Technical Committee (member)..... J.F. Gransden
- (secretary)..... A.T. Lloyd

CANADIAN COAL PETROGRAPHERS GROUP (member)..... J.G. Jorgensen
(secretary)..... B.N. Nandi

CANADIAN GAS ASSOCIATION
- Standards Committee (member)..... G.K. Lee
- Seasonal Performance of Gas-Fired Appliances..... A.C.S. Hayden
- Industrial and Commercial Gas Burners..... F. Preto
- Industrial and Commercial Gas Package Furnaces/Boilers... F. Preto
- Industrial and Commercial Atmospherically-Fired Vertical Flue Boilers and Hot Water Supply Heaters (member)..... F. Preto

CANADIAN HOME BUILDERS ASSOCIATION
- Task Force on Future Space Conditioning Systems (chairman)..... A.C.S. Hayden
- Committee on Controlled Ventilation and Heat Recovery (member)..... A.C.S. Hayden
- Committee on R2000 Technical Requirements (member)..... A.C.S. Hayden
- Technical Research Committee (members)..... A.C.S. Hayden
  ..... F. Preto
  ..... S.W. Lee

CANADIAN INSTITUTE OF ENERGY (director)..... E.J. Anthony
- Ottawa Branch (president)..... E.J. Anthony
- Ottawa Branch (vice-president)..... S.W. Lee
- Ottawa Branch (treasurer)..... F. Preto

CANADIAN INSTITUTE OF FLUIDIZED BED TECHNOLOGY (president).... E.J. Anthony
(secretary).... D.L. Desai
(director)..... F. Preto

CANADIAN SOCIETY FOR CHEMICAL ENGINEERING
- Ottawa Section Executive (past chairman)..... J. Chase
  (chairman)..... V. Allenger
  (member at large)..... J. Monnier
- Continuing Conference Program Subcommittee
  - Local Section (representative)..... J.F. Kriz

CANADIAN STANDARDS ASSOCIATION
- Committee on Oil Heating Systems (member)..... A.C.S. Hayden
- Subcommittee on Chimney Dampers (member)..... A.C.S. Hayden
- Air Pollution Control (executive)..... H. Whaley
- Incinerator Performance (member)..... F.D. Friedrich
- Steering Committee on Fire Safety and Combustion (member) A.C.S. Hayden
- Oil Burning Equipment (member)..... A.C.S. Hayden
- Retrofitting of Oil Burners (member)..... R.W. Braaten
- Sampling Emissions and Measurements (chairman)..... H. Whaley
- Emissions and Efficiency of Solid Fuel Appliances (member)..... R.W. Braaten
- Committee on Energy Evaluation of Houses (member)..... A.C.S. Hayden
- Subcommittee on Analytical Techniques for Housing (member)..... A.C.S. Hayden
- Task Group on Controlled Ventilation in Housing (member)..... A.C.S. Hayden
- Committee on Ventilation in New Housing (member)..... A.C.S. Hayden
- Installation Code for Solid Fuel Appliances (vice-chairman)..... R.W. Braaten
- Task Group on Combustion Air Provision in Tight Housing (chairman)..... R.W. Braaten
- Committee on Solid Fuel-Fired Central Heating Systems (member)..... A.C.S. Hayden
- Committee on Energy Evaluation of Houses (member)..... A.C.S. Hayden
- Committee on Masonry Chimneys and Fireplaces (members)... A.C.S. Hayden
  ... F. Preto

Executive Management Committee on Venting Systems
(members)..... A.C.S. Hayden
..... F. Preto
Seasonal Efficiency of Oil Burning Appliances (chairman). A.C.S. Hayden
Committee on Requirements for Residential Ventilation
(members)..... A.C.S. Hayden
..... F. Preto

CANADIAN SYMPOSIUM ON CATALYSIS (10th)
(session organizer and co-chairman)..... J.R. Brown

CANADIAN SYMPOSIUM ON SURFACE SCIENCE (14th)
Surface Canada 88 (session organizer and co-chairman).... J.R. Brown

CHEMICAL INSTITUTE OF CANADA
Analytical Chemistry Division (member)..... J.R. Brown
Catalysis Division (chairman)..... J.F. Kriz
Executive Committee (member at large)..... J.R. Brown
Ottawa-Hull Section Executive Committee
(ex-officio member)..... J. Monnier
Surface Science Division (member)..... J.R. Brown

FERROUS INDUSTRY RESEARCH ASSOCIATION
Technical Committee (member)..... C.J. Adams

HOUSING AND URBAN DEVELOPMENT ASSOCIATION OF CANADA (HUDAC)
Future Space Conditioning Requirements (chairman)..... A.C.S. Hayden
Controlled Ventilation and Heat Recovery (member)..... A.C.S. Hayden
Technical Research Committee (member)..... A.C.S. Hayden

NATIONAL HEAT PUMP COORDINATING COMMITTEE (chairman)..... M. Wiggin

PROFESSIONAL INSTITUTE OF THE PUBLIC SERVICE
Committee on Energy Research and Development (chairman).. M. Wiggin

UNDERWRITERS LABORATORIES OF CANADA/CANADIAN STANDARDS ASSOCIATION
Joint Committee on Wood Burning Appliances (member)..... A.C.S. Hayden

UNIVERSITY OF REGINA, ADVISORY BOARD
Coal Science Group (member)..... J.F. Kelly

APPENDIX D

CONTRACTS, RESEARCH AGREEMENTS AND COST RECOVERY WORK

CONTRACTS

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Investigation of separation and analytical methods for the characterization of bitumen from fireflood recovery operations	Alberta Research Council	R. Lafleur	C
Steam injection experiments in scaled physical models for simulation marginal reservoirs	University of Alberta	A. George	C
Numerical simulation of steam injection in bitumen and heavy oil reservoirs - Phase II - Development of methodology for a 3-dimension grid simulator	University of Toronto	R. Lafleur	C
Steam recovery processes with the addition of non-condensable gases - a mechanistic study	Geotechnical Resources	A. George	C
Extraction and characterization of crude oils from primary and enhanced oil recovery production	Alberta Research Council	R. Lafleur	IP
Study of the effect of thermal alteration on conformance efficiency in in situ thermal recovery process	Nova Husky Research	R. Lafleur	IP
Evaluation of a heavy oil recovery process using a novel combination of injectants	Sheridan Technical Assoc.	R. Lafleur	IP
Impact of steam additives on the productivity of the cyclic steam stimulation process	Gulf Canada	R. Lafleur	IP
Field test of a novel microbial system to improve reservoir conformance in a watered-out heavy oil field	Husky Oil	A. George	IP
Steam injection experiments in a scaled physical model - Phase III	University of Alberta	R. Lafleur	IP
Flocculation of asphaltenes in bitumen, heavy oil and asphalt solutions	Chemex Laboratories	R. Lafleur	IP

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
A feasibility study of the soluble-vapour, gravity assisted recovery technique for heavy crudes and bitumen	University of Calgary	A. George	IP
Demonstration of the use of Taciuk processor to treat heavy oil wastes, emulsions, sludges and spills	Environment Canada	A. George	C
Development of a five-year biotechnical research program for Energy Research Laboratories	McIntyre Engineering	A. George	IP
AOSTRA/CANMET underground test facility	AOSTRA	A. George	IP
AOSTRA/industry upgrading residue utilization project	AOSTRA	F. Friedrich	IP
Experimental evaluation of catalyst deactivation caused by asphaltene absorption	Newgrade Energy Inc.	M. Sekhar	IP
Separation and characterization of surfactants present in emulsions produced in enhanced oil recovery processes	C.A. Shook Consulting Ltd.	S. Coulombe	C
Catalytic hydrocracking of heavy oils in a layered fixed bed	Newgrade Energy Inc.	J. Kriz	IP
Biotechnological methods of up-grading bitumen, heavy oil and residue	University of Waterloo	H. Sawatzky	IP
Processing studies of bitumens/ heavy oils produced by recovery methods of diverse nature	Saskatchewan Research Council	H. Sawatzky	IP
Development and evaluation of catalysts for hydrogenation of raw Cold Lake pitch	Guelph Chemical Laboratories	M. Ternan	C
Upgrading heavy oil emulsions with carbon monoxide or synthesis gas	Gulf Canada	T. de Bruijn	IP

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Technologie des réacteurs à jet: application a l'hydrocraquage des huiles lourdes	University of Sherbrooke	W. Dawson	IP
Chemical transformations during residues upgrading - catalytic and thermal	Nova Husky Research	M. Ternan	IP
Hydrodynamic characteristics of hydrocarbon systems	University of Waterloo	T. de Bruijn	C
Novel scheme for primary upgrading of heavy oil	Nova Husky Research	K. Belinko	IP
Upgrading of oil residues from the petroleum industry program	Ultramar Canada Ltd.	J. Monnier	IP
Effect of pressure and temperature on the surface tension and viscosity of hydro oils	University of Waterloo	T. de Bruijn	IP
Ultrafiltration of crude oil for metals, sulphur and nitrogen removal	National Research Council	B. Farnand	C
Hydrocracking of individual components isolated from heavy oils and residual feeds	University of Sherbrooke	W. Dawson	IP
Modelling for reaction kinetics and prediction of product yields and quality in heavy oil and bitumen upgrading processes	Thornlea Technology Ltd.	D. Liu	IP
Compositional analysis of hydrotreated middle distillates from synthetic crudes by mass spectrometry	Petro-Canada Inc.	M. Wilson	IP
Analysis of synthetic crude middle distillate fractions by C-13 NMR	Carleton University	M. Wilson	IP
Dearomatization of synthetic crude	University of Ottawa	J. Kriz	C

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Development of metal cluster catalysts for conversion of middle distillate fractions in synthetic fuels	University of Toronto	M. Wilson	IP
Selective extraction of nitrogen content from fluid catalytic cracking feedstock	Petro-Canada Inc.	P. Chantal	C
Investigation of process conditions for the synthesis of liquid distillates from light olefins and methanol	Petro-Canada Inc.	B. Farnand	C
Degradation study of metals-tolerant fluid catalytic cracking catalysts by molecular probes	Petro-Canada Inc.	S. Ng	IP
Detailed study of the influence of experimental conditions on retention time in size exclusion chromatography of bitumens/heavy oils/asphaltenes	Guelph Chemical Laboratories	S. Coulombe	C
Separation of sulphurous compounds in synthetic crude fractions	Geotechnical Resources Ltd.	P. Chantal	IP
Reverse osmosis separation of methanol from ethers and unreacted olefins	Zenon Environmental Ltd.	B. Farnand	IP
Techno-economic evaluation of conventional synthetic and oxygenated gasoline blending components	Petro-Canada Inc.	H. Sawatzky	C
Determination of Co-Mo-Al thin film catalyst activity for hydroprocessing of synthetically derived distillates - Phase 5	University of Western Ontario	J. Brown	IP
Shock tube combustion of aromatic and naphthenic hydrocarbons in jet fuels derived from Canadian oil sands	York University	M. Sekhar	C

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Quantitative elemental analysis by PIXE of catalysts, fossil fuels and related residues	Elemental Analysis Corp.	J. Brown	IP
Improved cobalt promoted hydrodesulphurization catalysts for Syncrude distillate uporading	Simon Fraser University	J. Brown	IP
Characterization of supported metal catalysts and solid fuel residues by powder X-ray diffraction	Lakefield Research Ltd.	J. Brown	IP
Characterization of fossil fuels, their residues and refinery related solid materials using synchrotron radiation techniques	University of Western Ontario	J. Brown	IP
Characterization of fossil fuels, their residues and refinery related solid materials by physical methods	Ontario Research Foundation	J. Brown	IP
Chemical characterization of fossil fuels, their residues and refinery related products by surface sensitive analytical methods	Charles Evans and Associates	J. Brown	IP
Characterization of the mineralogical content of selected Canadian coals by the active image/EDX technique	Geofuels Ltd.	J. Brown	IP
Characterization of fossil fuels, their residues and petroleum refinery related materials by FTIR	Advanced Fuels Research Ltd.	J. Brown	IP
Utilization of CR4's of ethylene plants and FCC units through transformation to octane boosters for unleaded gasoline	Nova Husky Research	J. Kriz	IP
Effect of the composition of asphalt cement on its rheological properties	Imperial Oil Limited	H. Sawatzky	IP
Effect of wax content on the rheological properties of asphalt cements	Imperial Oil Limited	H. Sawatzky	IP

C = Completed
IP = In Progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Fluid catalytic cracking (FCC) catalyst fabrication	Carbovan Inc.	C. Fairbridge	IP
Deasphalting of non-conventional residues and catalytic cracking of de-asphalted oils by metal-tolerant catalyst	Sheridan Technical Assoc. Inc.	S. Ng	IP
Development of absorption simulation software	University of Western Ontario	P. Chantal	IP
Application of a pulse micro-catalytic reactor for the kinetic modelling of catalytic cracking of gas oil	University of Western Ontario	S. Ng	IP
Evaluation of two-stage catalytic hydroprocessing of Syncrude gas oil	Petro-Canada Inc.	J. Monnier	IP
Upgrading of synthetic crude distillates with commercial hydrotreating catalysts	Stearns Catalytic Ltd.	M. Sekhar	C
Conversion du méthane en utilisant une cathode creuse	Univ. du Québec à Chicoutimi	G. Jean	C
Conversion of synthesis gas to diesel fuel using a novel catalyst	Centre de recherche industrielle du Québec	G. Jean	C
Conversion of synthesis gas into diesel fuel using catalyst ZKQ	Centre de recherche industrielle du Québec	G. Jean	IP
Natural gas conversion to liquid fuels over superacids	Guelph Chemical Laboratories	V. Allenger	C
Carbon molecular sieve-based synthesis catalysts for diesel fuel production	Guelph Chemical Laboratories	J. Galuszka	IP
Preparation and pretreatment of trifunctional deoxygenation catalysts	Laval University	G. Jean	C

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Application of pseudoadiabatic catalytic reactor for the conversion of synthesis gas to blending stocks	University of Western Ontario	G. Jean	C
Oxidative coupling reactions	Catam Research Inc.	M. Ternan	IP
Design and testing of mixed oxyde catalysts for the direct conversion of methane to hydrocarbon through oxidative coupling	Institute de recherche d'Hydro-Québec	G. Jean	IP
Recent advances in alkane activation	Catalytica Associates	G. Jean	C
Direct conversion of methane to higher hydrocarbons through oxidative coupling	Alberta Research Council	J. Galuszka	IP
Direct methane conversion to light olefins	Guelph Chemical Laboratories	V. Allenger	IP
Homogeneous, thermal conversion of methane to ethane and other saturated hydrocarbons	University of Ottawa	J. Galuszka	IP
Contribution to the Gas Research Institute for natural gas conversion studies under the Industrial Associate Program	Gas Research Institute	G. Jean	IP
Catalytic two-stage liquefaction of Nova Scotia coals	Nova Scotia Research Foundation	P. Rahimi	C
Low temperature Mössbauer spectroscopy of tin catalysts	Concordia University	J. Monnier	IP
Exploratory investigation of solids removal from CANMET coprocessing residue	SNC Inc.	M. Ikura	IP
Physical and chemical changes of treated coals	Cyclone Engineering	S. Fouda	C

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Flash hydropyrolysis of Prince mine coal	Ontario Research Foundation	M. Ikura	C
Fabrication and installation of a pilot plant electronic instrumentation system	Cambrian Engineering	J. Chase	IP
Liquefaction studies on Nova Scotia coals	Nova Scotia Research Foundation	P. Rahimi	C
Isotopic mass balance measurements for determination of coal-derived liquid contribution to coprocessing distillates	University of Alberta	P. Rahimi	IP
Characterization of solid residues from coprocessing	University of Regina	W. Dawson	IP
Process evaluation of an integrated retorting co-combustion system using fixed bed technology	Monenco Consultants Ltd.	M. Ternan	C
Process evaluation of an integrated retorting co-combustion system using spouted bed technology	Polymath Energy Consultants Ltd.	M. Ternan	C
Preparation of pitch-water slurry	Farrington, Lockwood Co. Ltd.	A. Palmer	C
A review of recent developments in hot gas clean-up research	TransAlta Utilities	E. Furimsky	C
To evaluate the Kellog-Rust-Westinghouse integrated gasification-combined cycle demonstration stage process for conversion of Alberta's Highvale coal to electricity	TransAlta Utilities	E. Furimsky	IP

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Gasification of Canadian coals using pilot plant pressurized gasifier	TransAlta Utilities	E. Furimsky	IP
Plastofrost study of Western Canadian coking coals	University of Waterloo	J. Price	C
Identification of chemical sites on coal surfaces by SIMS, SEM-EDS and XPS	University of Western Ontario	J.A. MacPhee	C
Coal devolatilization in an entrained flow reactor	University of Ottawa	P.M. Hughes	IP
Computer modelling of coal combustion	Thermal Science Ltd.	P.M. Hughes	IP
Study of the characterization of coals using photoacoustic infrared Fourier transform spectroscopy and chemical transformation and derivatization - Phase II	Saint Francis Xavier Univ.	J.A. MacPhee	C
Development of a three dimensional mathematical model of atmospheric fluidized bed combustion	Queen's University	E.J. Anthony	IP
Sorbent optimization for FBC technology	New Brunswick Electric Power Commission	V. Razbin	IP
Testing of Nova Scotia coal and limestone in the Chatham FBC boiler	Nova Scotia Power Company	V. Razbin	IP
10 in. Co-Ax press trials - lignite and bituminous coals	Stake Technology Ltd.	D. Desai	C
Investigation of sulphur capture wiring circulating fluidized bed combustion of Eastern Canadian coals	New Brunswick Research and Productivity Council	I. Lau	IP

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Circulating fluidized bed combustion of Western Canadian fuels	University of British Columbia	E.J. Anthony	IP
Utilization potential of circulating fluidized combustion residues in construction application	Dearborn Environmental Consultants	E.J. Anthony	IP
Combustion tests on dense coal CWF in a small tunnel furnace	Technical University of Nova Scotia	K. Thambimuthu	C
Tests on NRC atomizer/burner system during the Charlottetown CWF demonstration	National Research Council	K. Thambimuthu	C
Coal water fuel conversion of an industrial oil-fired package boiler in a pulp and paper plant, Hansport, Nova Scotia	Cape Breton Development Corporation	K. Thambimuthu	IP
Combustion testing of EMR/CANMET CWF burners in a compact oil-designed utility boiler	Maritime Electric Company Ltd.	H. Whaley	IP
Mechanical and economic assessment of micronized coal pulverizers	Stone & Webster Canada Ltd.	R. Philp	C
Air blast atomization of coal-water fuels	Nova Scotia Research Foundation Corporation	K. Thambimuthu	IP
Optimization of distributed mixing burner parameters during coal combustion	New Brunswick Electric Power Commission	G. Lee	IP
Performance evaluation and optimization of low NO_x/SO_x burners and sorbent injection system at CFB Gagetown	ADI Limited	G. Lee	IP
IEA Coal Combustion Science, Annex II	International Energy Agency	H. Whaley	IP

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
IEA - Low NO_x coal combustion agreement, Annex V	International Energy Agency	G. Lee	C
Coal research implementation agreements, British Coal Research, UK	International Energy Agency	D. Reeve	C
Development of high efficiency oil-fired warm air furnace and domestic water heater	Clare Brothers	A.C.S. Hayden	C
Perform prediction CCRL tunnel furnace coal combustion	Imperial College of Science	H. Whaley	C
Chemical heat pump study - Phase II	Delta Projects Inc.	M. Wiggin	C
Combustion enhancement by induced Ray Leigh instability	B.C. Research	K. Tait	C
Comparative evaluation of hot water and steam based distribution system for district heating	IEA Consulting Group Ltd.	M. Wiggin	C
Direct contact heat exchangers for heat pump application	St. Mary's University	M. Wiggin	IP
Evaluation of zeolite and sodium hydroxide chemical heat pumps	Acres International	M. Wiggin	C
Heat pump/heat exchanger state of the art review and summary report. IEA advanced heat pump implementing agreement	National Research Council	M. Wiggin	C
Testing of advanced fluids, particularly R-113, in a high temperature steam generating heat pump	National Research Council	M. Wiggin	C
Meeting - IEA district heating implementing agreement experts on low cost distribution system technology	Comstock International	M. Wiggin	C

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Development of high temperature working fluids and mixed refrigerants for industrial heat pumps	National Research Council	M. Wiggin	C
Development of ground source heat pump evaporators including monitoring of demonstration installation; representation on IEA annexes and development of direct expansion technology	National Research Council	M. Wiggin	IP
Study of the application of condensing heat recovery to enhanced oil recovery steam generators	Monenco Consultants Ltd.	A.C.S. Hayden	C
Participate in multi-client study to develop database on major industrial energy consumers in Ontario by Ceri Energy Research Ltd.	EMR - Energy Conservation Branch	A.C.S. Hayden	IP
Agreement for a program of R&D on advanced heat pumps	International Energy Agency	M. Wiggin	IP
IEA energy technology database - contribution only	International Energy Agency	M. Wiggin	IP
High temperature EPR studies of the thermolysis of heavy oil and its components	University of Guelph	D. Patmore	C
Evaluation of atmospheric flash pyrolysis of coprocessing residues	University of Waterloo	S. Fouda	C
Development of gas-fired domestic water heater	Modern Times Auto Marine Ltd.	F. Preto	C
A retrofit package for gas-fired furnaces - Phase III	Clare Brothers	A.C.S. Hayden	C
Revise and update instrumentation loop diagrams and panel drawings for coprocessing pilot plant	Monenco Consultants Ltd.	J. Chase	C

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Optimizing the performance of the low NO_x/SO_x burners and limestone system at CFB Gagetown	G.A. Robb Associates	G.K. Lee	C
Chemical heat pump study - Phase II	Stearns Catalytic Ltd.	M. Wiggin	C
Upgrading heavy oil emulsions with carbon monoxide or synthesis gas	Petro-Canada Inc.	T. de Bruijn	C
Membrane processing of oilfield produced water for steam generation	Zenon Environmental	B. Farnand	C
Preparation and catalytic activity of supported group V B and VI B metal clusters	University of Calgary	C. Fairbridge	C
Development of method suitable for petroleum refinery	Chemex Laboratories Ltd.	S.W. Lee	C
Engineering evaluation of fluidized bed demo at CFB Summerside, P.E.I.	Monenco Consultants Ltd.	F. Friedrich	C
Hydrocracking of individual components isolated from heavy oil and residual	Université de Quebec à Chicoutimi	W. Dawson	C
Bench scale evaluation of anthracite/thermal coal mixtures for a pulverized firing system	Gulf Canada	J. Wong	C
Departmental, environmental and socio-economic study on waste disposal	EMR Admin. Prog. FMB	F.T.T. Ng	C
Mathematical modelling of coprocessing kinetics	Lobbe Technologies Ltd	S. Fouda	C
Fluid catalytic cracking of non-conventional gas oils by an octane-enhancing catalyst and a metals-tolerant catalyst	Sheridan Technical Assoc. Inc.	S. Ng	C
Processability and reactivity of heavy ends	Petro-Canada Inc.	S. Coulombe	C

C = Complete
IP = In progress

TITLE	CONTRACTOR	SCIENTIFIC AUTHORITY	STATUS
Selective identification of olefins and paraffins in middle distillates from synthetic crude oils	Petro-Canada Inc.	S. Coulombe	C
Conversion of methane over selected solid catalysts	Petro-Canada Inc.	V. Allenger	C
Impact drilling and completion fluids on productivity heavy oil recovery process	Petro-Canada Inc.	A. George	C
Combustion tests on dense coal CWF in a small tunnel furnace	Technical University of Nova Scotia	K. Thambimuthu	C
Opportunities in the catalytic conversion of natural gas to liquids	Stanford Research Institute	C. Fairbridge	C
Assessment of the potential for commercialization of a low severity catalytic hydrogenation process for middle distillate upgrading	RTM Engineering Ltd.	M. Skubnik	C
IEA district heating implementing agreement - Annex II, Advanced fluids project modelling services	Public Works Canada	M. Wiggin	C
Hydrocracking of individual components isolated from heavy oil and residual	University of Sherbrooke	W. Dawson	C
Circulating bed combustion/pitch and tar	University of British Columbia	E.J. Anthony	C
Characterization of solid residues from coprocessing	University of Regina	W. Dawson	C
Demonstration of Taciuk extraction/upgrading technology	AOSTRA	A. George	C
Reforming of non-conventional or synthetic naphthas to high-octane transportation fuels	Petro-Canada Inc.	J. Kriz	C

C = Complete
IP = In progress

RESEARCH AGREEMENTS

	TITLE	FUNDS AWARDED ($K)	CONTACT OFFICER
Atlantic Coal Committee	Air Blast Atomization of Coal-Water Fuels (contract with Nova Scotia Research Foundation)	46	K.V. Thambimuthu
St. Mary's	Phase change salts for thermal storage	5.2	M. Wiggin
Queen's	Industrial applications of microwave technology to catalytic processes	10	J.F. Kriz

COST RECOVERY WORK - (NON-ROUTINE)

JOB NO.	COMPANY/PROJECT	COST ($K)	% RECOVERY
025407	Northland Power Co. Technical evaluation of a wood-refuse boiler for cogeneration	14.0	67%
025408	B.C. Hydro International Ltd. Design of coal combustion research facility - Phase I and II	140.0	67%
025409	AOSTRA Combustion tests on AOSTRA upgraded residues - Phase I, II and III	26.3	100%
025410	Cape Breton Development Corp. Combustion testing of CWF produced by CBDC in pilot-scale research boiler	19.1	67%
025411	Luscar-Sterco Ltd. Combustion performance of Coal Valley coal	1.0	100%
025412	Syncrude Canada Ltd. Characterization of solid residues from the Syncrude fluidcoker	14.5	100%
025413	Petro-Canada Microscopic analysis of residues from CANMET demo plant in Montreal	12.1	100%
025414	AMOCO Corporation Pilot plant test of Amoco tar sand bitumen	30.0	100%
025415	Multi Biotech Inc. Evaluation of natural gas processing scheme	15.6	100%

COST RECOVERY WORK - (ROUTINE - INCLUDES EXCHANGE ANALYSES)

Algoma Steel Corporation Ltd.
B.C. Hydro International Ltd.
Bioshell Inc.
Cape Breton Development Corp.
Crows Nest Resources Ltd.
Dofasco
Environment Canada
Irving Oil Ltd.
Kidd Creek Mines Ltd.
Luscar Sterco Inc.
Northland Power Co.
Ontario Hydro Research Division
Ontario Ministry of Transportation and Communications
PEI Fishermen's Association
Department of Public Works
Smoky River Coal Ltd.
Veterans Affairs
Westar Mining Ltd.
Westar/Algoma

TOTAL VALUE = $230 K

APPENDIX E

CONTACTS, MEETINGS, FIELD TRIPS, AND JOINT CONSULTATIONS

CONTACTS, MEETINGS AND FIELD TRIPS

ERL remained as the national laboratory in fossil energy technology, in particular in the areas of heavy oil and bitumen recovery and upgrading and advanced coal to electricity processes which allow coal to be burned cleanly and at increased energy conversion efficiencies. Also ERL's role in residential and industrial energy conservation technologies expanded to include heat pump and district heating technologies.

In line with CANMET's mission to perform and sponsor predominantly commercial and cost-shared research, technology and development in partnership with its clients, contacts were maintained with other research organizations and private sector companies and agencies to enhance technology transfer and promote the exchange of information relating to research programs. This aspect of ERL's activities assumed a new importance with the requirement to demonstrate and achieve closer working relationships with industry. Efforts were made within the scope of these contacts to encourage increased private sector participation in research programs. Intelligence flowing from these contacts and also from international contacts, for example through direct participation by ERL scientists in International Energy Agency technology agreements, allowed ERL to provide advice to the department and to make adjustments to its program plans.

ERL scientists were active in 40 conferences across the continent and in other parts of the world at a cost of approximately $40,000.

During 1987/88 ERL hosted visits by scientific and technical personnel from many parts of the world and conducted numerous tours of its facilities. ERL remains in the forefront of energy research and cooperates with others through the exchange of information and granting programs to private industry and universities.

The research agreements and contracts awarded to industry, private consultants, and universities continued to grow, necessitating continued technical supervision and travel by staff. In addition to consultations related to the contracts in Appendix D of this report, many visits were made to discuss and evaluate new proposals or to make preliminary plans for contract work in the next fiscal year. The development of the CANMET shared-cost energy conversion program, for example, required extensive contact by ERL technical and scientific staff.

On an individual basis, ERL scientists engage in external consultations through their membership in technical committees as indicated in Appendix C. Substantial contributions were made to standardization organizations such as ISO, CSA, and ASTM. The committees of these organizations include representatives from public and private sectors as well as from academic institutions.

JOINT PROVINCIAL/INDUSTRY/FEDERAL/INTERNATIONAL CONSULTATIONS

PROVINCIAL

Alberta Department of Energy and Natural Resources
Alberta Office of Coal Research and Technology
Alberta Oil Sands Technology and Research Authority (AOSTRA)
Alberta Power Corporation
Alberta Research Council
B.C. Energy, Mines and Petroleum Resources
B.C. Hydro International, Vancouver
B.C. Research, Vancouver
Carleton University, Ottawa
Centre de recherche industrielle du Québec
Conseil de la science et de la technologie, Ste. Foy, Québec
École polytechnique, Montréal
Hydro Québec
Institut de recherche d'Hydro Québec (IREQ)
Institut national de la recherche scientifique (INRS), Varennes, P.Q.
McGill University, Montreal
New Brunswick Department of Industry and Regional Expansion
New Brunswick Electric Power Commission
New Brunswick Research and Productivity Council
Newfoundland Mines and Energy
Nova Scotia Energy and Mines
Nova Scotia Power Corporation
Nova Scotia Research Foundation, Dartmouth, N.S.
Ontario Hydro
Ontario Ministry of Energy
Ontario Research Foundation
PEI Energy Corporation
Petroleum Recovery Institute, Alberta
Queen's University
St. Mary's University, Halifax
Saskatchewan Research Council
Saskatchewan Energy and Mines
Saskatchewan Power Corporation, Regina
Technical University of Nova Scotia, Halifax, N.S.
University of Alberta
University of Calgary
University of Laval
University of Ottawa
University of Regina
University of Saskatchewan
University of Sherbrooke
University of Toronto
University of Waterloo
University of Western Ontario
University of Windsor

INDUSTRY

Alberta Energy Company Ltd., Calgary
Alberta Oil Sands Equity
Alberta Power, Calgary
Alcan International, Arvida, P.Q.
Algoma Steel Corp., Sault Ste. Marie, Ont.
Artec Canada Limited, Kanata
BP Canada Inc., Calgary
Breslube Enterprises, Kitchener
Byron Creek Collieries, Calgary
Canada Cement Lafarge, Montreal, P.Q. and Exshaw, Alta.
Canadian Business Magazine
Canadian Carbonization Research Association
Canadian Coal Liquefaction Company, Edmonton
Canadian Electrical Association
Canadian Energy Developments, Inc.
Canadian Energy Research Institute, Calgary
Canadian Gas Association, Toronto
Canadian Industries Limited Inc., Toronto
Canadian Occidental
Canadian Pacific Consultants Services, Calgary
Canadian Standards Association
Cape Breton Development Corporation
Carbochem Inc.
Chemex Labs, Alberta Ltd.
Chromasco, Haley Station, Ont.
CIMCO, Toronto, Ont.
Clare Bros., Cambridge, Ont.
CMEL Enterprises Inc., Spencerville, Ont.
Coal Association of Canada
Combustion Engineering Canada Inc., Ottawa
Computer Modelling Group
Consumer's Cooperative Refineries, Regina
Currie Products, Hamilton
Cyclone Engineering, Edmonton
Dedesco Industries, Kanata
Dearborn Chemical Co. Ltd., Mississauga, Ont.
Denison Mines Ltd., Vancouver
Dofasco, Hamilton
DuPont Canada, Mississauga, Ont.
E.B. Eddy Forest Products Ltd., Ottawa
Earth Systems Ltd., Elmira, Ont.
Enterprise Cape Breton, Sydney
Esso Resources Canada Ltd., Calgary
Ferrous Energy Research Association
Fording Coal Limited, Calgary
Gaz métropolitan, Montreal
Geotechnical Resources Ltd., Calgary
Guelph Chemical Laboratory
Gulf Canada Ltd., Sheridan Park, Ont.
Gulf Canada Resources Ltd., Devon, Alta.

INDUSTRY (cont'd)

Hatch Associates, Calgary
Husky Oil Operations
Idemitsu Kosen, Calgary
IEA Consulting, Charlottetown, PEI
Industrial Membrane Research Corporation, Nepean
Intercity Gas Utility, Vancouver
IOTECH Corp., Ottawa
IREQ, Varennes, P.Q.
Irving Oil Refinery, St. John, NB
J.T. Jackson Association, Ottawa
Lakewood Manufacturing, Bobcaygeon, Ont.
Lavalin Inc., Toronto
Lobbe Technologies
J.H. Lock & Sons Ltd., Dartmouth, NS
Luscar Ltd., Edmonton
Manalta Coal Limited, Calgary
Maritime Electric Co. Ltd., Charlottetown, PEI
MBB Mechanical Services Ltd., Halifax, NS
McLaren Plansearch, Toronto
Membrane Technology Consultants, Nepean, Ont.
Michel Boyd & Associates Technology (MBATEK), Montreal
Minas Basin Pulp and Paper Company, Hantsport, NS
Monenco Enterprises, Calgary and Toronto
Murphy Oil, Calgary
Norac Technologies, Inc.
Northland Power, Toronto
Nova Husky Research Corporation, Calgary
Pancanadian
Partec Lavalin, Montreal
Petro-Canada
Petroleum Research Institute
Phoenix Oil Refiners
Polysar
Prairie Coal
PTL Research, Fredericton, NB
Pulp and Paper Research Institute of Canada (PAPRICAN) Montreal
QIT - Fer et titane Inc.
Quantetics Corporation, Ottawa
Regency Industries, Delta, BC
Richard Brancher Research Limited, Ottawa
SACDA, London, Ont.
Sceptre Resources Ltd.
Shell Canada Research Centre, Oakville, Ont.
Sheridan Technical Associates, Mississauga, Ont.
Simtech Consulting
Smoky River Coal Company, Grand Cache, Alta.
SNC Inc., Montreal
Stelco, Burlington, Ont.
Suncor Inc., New Glasgow, NS
Sunroot Energy Limited, Mississauga, Ont.
Sunwell Engineering, Woodbridge

INDUSTRY (cont'd)

Synco Oil and Chemical Corp., Saskatoon
Syncrude Oil Research Department, Edmonton
Texaco Canada Research
Three-D Geoconsultants Ltd., Fredericton, NB
Toronto District Heating Corporation
TransAlta Utilities, Calgary
UMATAC Industrial Processes
Ultramar Canada Inc., Montreal
Union Gas Ltd., Chatham, Ont.
Volcano Inc., St. Hyacinthe, PQ
Westar Mining, Sparwood, BC
Winestock Petroleum Consulting Ltd., Edmonton
W.J. Howell Engineering Ltd., Scarborough
W.R. Grace, Valleyfield, PQ
X-ray Assay Laboratories, Toronto
Zenon Environmetal, Burlington, Ont.
Zeton Inc., Burlington, Ont.

FEDERAL

AECL, Chalk River
AECL, Pinawa, Manitoba
Canadian Patents Development Limited
CBC Ottawa
CFB Gagetown, New Brunswick (DND)
Department of Regional Industrial Expansion
Environment Canada, Burlington and Ottawa
External Affairs
National Defence Canada
National Museums
National Research Council
Natural Sciences and Engineering Research Council
Public Works Canada
Science Council of Canada
Transport Canada

INTERNATIONAL

UNITED STATES

Alliance to Save Energy, Washington, D.C.
American Society of Mechanical Engineers, Environmental Control Division
American Society for Testing and Materials, Philadelphia
Amoco Research, Chicago
ANG Coal Gasification Co., Beulah, ND
Arcanum Corp., Michigan
Argonne National Laboratory, Chicago
Auburn University, Auburn, Alabama
Brigham Young University, Provo, Utah
Brookhaven National Laboratories, Upton, NY
CBI Industries Inc., Chicago
Combustion Engineering, Windsor, Connecticut
District Energy, St. Paul, Minnesota
Dykema Engineering, Westlake, CA
EER Corporation, Irvine, CA
Engelhard Corporation, Edison, NJ
lorida Power and Light Company, Miami
Foster Wheeler Development Corp., New Jersey
Geodata Analysis, Kentucky Energy Cabinet, Lexington
Harshaw/Fitrol Partnership, Los Angeles, CA
Illinois State Geological Survey
Journal of Coal Quality, Kentucky
KRW Energy, Madison, Pennsylvania
National Institute for Petroleum and Energy Research, Bartlesville, OK
New Mexico Petroleum Recovery Research Center, Socorro, NM
New York State Energy R&D Authority, Albany, NY
Niagara Mohawk Power Co.
Oak Ridge National Laboratory, Oakridge, TN
Ohio State University, Columbus, Ohio
Revere Copper & Bars Inc., Rome, NY
Rheinische Braunkohlen-Union Kraftstoff, FRG
Rio Blanco Oil Shale Company, Denver, CO
Sandia National Laboratories
Seneca County Weatherization, Seneca Falls, NY
Shell Development Company, Houston, TX
Solv-Ex Corporation, Albuquerque, NM
Southern Company Services Inc., Birmingham, Alabama
T.A.S., Utah
United Engineers and Constructors, Philadelphia
University of Alabama, Tuscaloosa, Alabama
University of Pittsburgh, Pennsylvania
U.S. Chemical, Cincinnati, Ohio
U.S. Department of Energy
U.S. Department of the Interior
U.S. Environmental Protection Agency
U.S. Geological Survey
Utah Department of Transportation
W.S. Grace, Mass.

OTHERS

AMDEL Limited, Australia
Atomic Energy Research Est., Harwell, UK
British Brown-Boveri Ltd., Telford, UK
British Coal, Cheltenham, UK
Central Coal Mining Research Institute, China
Central Electricity Generating Board, Southampton, UK
China Electric Power Research Institute, Xian, China
China Ministry of Coal
Electricity Trust of South Australia, Adelaide
Elkraft, Denmark
Finnish District Heating Ass'n, Helsinki, Finland
German District Heating Association, Frankfurt, West Germany
Hokkaido University, Sapporo, Japan
Imperial College, London, UK
Institute Français du pétrole
Institute of Mining Research, Zimbabwe
Intevep S.A., Venezuela
International Energy Agency, London and Paris
International Flame Research Foundation, Holland
International Union of Heat Distributors, Durnten, Switzerland
Japan Agency of Natural Resources and Energy
Japan Development Bank
Kawasaki Steel Corporation, Chiba, Japan
KFA, Julich, West Germany
Kyoto University, Japan
Maraven, S.A., Venezuela
Metropolitan Copenhagen Heating Transmission Company, Denmark
National Chemical Laboratory for Industry, Tsukuba, Japan
National Energy Administration, Stockholm, Sweden
Netherlands Energy Development Col, Sittard, Netherlands
New Energy Development Organization, Tokyo
Northeastern University, Shenyang, China
Puerto Rican Electric Power Authority, San Juan, Puerto Rico
SINTEF, Tranheim, Norway
Sulzer, Winterthur, Switzerland
Swedish Council for Building Research, Stockholm, Sweden
Swedish State Power Board, Stockholm, Sweden
Thermal Power Engineering Research Institute, Xian, China
Tohoku University, Japan
Tokyo University
Tsinghua University, Beijing, China
University of Antwerp, Belgium
University of Cambridge, Cambridge, UK
University of Newcastle, Australia
University of Stuttgart, FRG
University of Surrey, Guildford, UK
University of Warsaw, Poland
University of Zhejiang, Hangzhou, China
Veba Oil, A.G., West Germany